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THE ROLE OF BASIC RESEARCH IN ECONOMIC COMPETITIVENESS

HEARING

BEFORE THE

SUBCOMMITTEE ON SCIENCE

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED SECOND CONGRESS

FIRST SESSION

JUNE 20, 1991

[No. 38]

Printed for the use of the
Committee on Science, Space, and Technology

U.S. GOVERNMENT PRINTING OFFICE

45-746 == WASHINGTON : 1991

For sale by the U.S. Government Printing Office
Superintendent of Documents, Congressional Sales Office, Washington, DC 20402
ISBN 0-16-035441-2

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H701-63

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THE ROLE OF BASIC RESEARCH IN ECONOMIC COMPETITIVENESS

THURSDAY, JUNE 20, 1991

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
SUBCOMMITTEE ON SCIENCE,
Washington, D. C.

The subcommittee met, pursuant to call, at 10:06 a.m., in Room 2325, Rayburn House Office Building, Hon. Rick Boucher [chairman of the subcommittee], presiding.

Mr. BOUCHER. The subcommittee will come to order.

This morning the Subcommittee on Science begins hearings on the question of the role of basic research and economic competitiveness. Americans have long understood that basic research is the foundation upon which our technologically sophisticated and economically advanced society rests. Public support for basic research has been broad-based and strong, as demonstrated by steady overall increases in Federal funding for science. The Nation's research universities today are the envy of the world. To gauge how successful these institutions have become, we need only look at the number of faculty and students that are attracted from throughout the world to U.S. science and engineering departments. The value of university contributions to research and to training of the next generation of scientists and engineers has been an unquestioned element of American public policy since World War II.

The relevance of science in general, and university research in particular, to economic prosperity is not a new American public policy issue. Thomas Jefferson's vision of a partnership of scholarship with the arts and industry, the creation of land grant colleges in 1862, and the establishment of the World War II Office of Scientific Research and Development all struck resonant chords of public and academic support. Recently, however, as we struggle to remain internationally competitive, we are focusing with renewed interest on the role of basic research in competitiveness.

During the past decade Japan and Western Europe have significantly increased research and development funding, and have aggressively directed their research efforts to areas that drive economic growth. We must also ensure that the vast scientific and engineering resources of our Nation's universities are focused effectively on achieving commercial success for American industry. These efforts historically have been undertaken through industry and university research partnerships. We will ask today how those partnerships are functioning.

Basic research in industry, while not as visible as its university counterpart, is another vital component of our Nation's effort to achieve international commercial success. Premier U.S. corporations, such as IBM, GE, and AT&T, proudly support laboratories devoted to basic research as the source of many of their next generation products. In general, only companies that have annual revenues in excess of $1 billion conduct research in their own laboratories, but many smaller companies have been attracted to university-industry consortia. Indeed, many are themselves spin-offs of research university efforts.

Industry support for basic research has shown steady real growth during the last 45 years in the United States. Although funding did not quite keep pace with inflation between 1987 and 1989, the National Science Foundation estimates that in 1990 industry spent nearly $4.5 billion to support basic research. That figure represents a real increase over inflation, and is particularly significant in view of the recessionary pressures that existed during the course of 1990 for industry to reduce costs. Steady growth in industry support for basic research confirms its economic value in the broadest sense. Can industry do more? How does this vital private sector research funding in the U.S. compare to expenditures of the private sector in our competitor nations? We will seek answers to these and other questions concerning the private role in basic research during the course of these hearings.

The purpose of the hearing today in a broad sense is to evaluate existing and alternative mechanisms to ensure an adequate level of basic research with economic potential. Our first panel today will review broad Federal and State goals and activities that are directed toward that end. The second panel will assess the contributions of two National Science Foundation-sponsored Engineering Research Centers, those at Purdue University and Columbia, from the perspective of the university host and also the industrial sponsor.

Before turning to our first panel of witnesses, the Chair would now recognize the ranking Republican member of this subcommittee, the gentleman from California, Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman. I too would like to welcome all the witnesses who will be testifying today. They all have very distinguished backgrounds, and I certainly feel that this will be a very informative and productive session. I would also like to take this opportunity to thank the chairman of the Science Subcommittee, Mr. Boucher, for scheduling such an important hearing.

One of the purposes of this hearing is to assess whether or not there is an adequate percentage of Federal basic research funding that is being targeted to fostering economic competitiveness. This is especially timely given the escalating R&D investments which are being made in Japan and West Germany and many other of our industrial countries. These countries have been successful in focusing their basic research into areas where there are potential commercial applications.

I am particularly interested in hearing about the effectiveness of the Engineering Research Centers both from the second panel of witnesses and from Mr. Erich Bloch, whom I think all of us know, who initiated the Centers while he was Director of the National Science Foundation. These Centers bring the university community

and industry together to conduct basic research which is vital to the next generation of technological advances. I will be interested also in hearing how compatible these two are, given that such research conducted by each typically has such diverse missions.

Again, I would like to thank all of the witnesses for being here, and you, Mr. Chairman, and look forward to the hearing and to all of the testimony.

Mr. BOUCHER. The Chair thanks the gentleman, and recognizes now the gentleman from Arkansas, Mr. Thornton, who has I think a very special interest in the subject matter that we're pursuing this morning. The gentleman, as I understand it, is working on a very broad-based initiative that would enhance various aspects of American economic life. In fact, I think he phrases it a Marshall Plan for the United States. So I'd be glad to recognize the gentleman at this time.

Mr. THORNTON. Thank you. Thank you, Mr. Chairman. And, indeed the role of science in stimulating economic competitiveness is a very important part of a comprehensive approach to develop a plan or procedures or strategy for applying the best of our ability to meeting America's needs, just as we did in meeting Europe's needs following World War II. I am not suggesting the Marshall Plan, but rather a comprehensive approach to solving our problems of competitiveness. And, indeed, science is a large mover in such an approach.

I must also confess to a little bit of deja vu as we begin this panel. It is so good to see Mr. Erich Bloch again and I'm looking forward to Dr. Likins' testimony, and Dr. Straub, who I hope I will have an opportunity of introducing before his testimony. A few years ago in this committee room I was interviewing or questioning Dr. Richard Atkinson, who was then the head of the National Science Foundation, and we were reviewing the peer reviewed NSF grants to different States and I asked Dr. Atkinson how much pure science research NSF was funding in Arkansas, and he said, "Mr. Chairman, I'll have to get that information to you following the hearing," and I went ahead. Well, immediately following the hearing he came up to the desk and said, "I knew the answer but I didn't want to put it in the record. Last year, unfortunately, Arkansas received only $15,000 from the National Science Foundation to fund basic research." And I said, "Well, I'm deeply concerned because we have good scientists and good capabilities there." And out of that conversation grew the initiation of the Experimental Program to Stimulate Competitive Research in America.[1] John Talmadge and I worked together in formulating a plan for that, and later on we'll be able to explore how the State of Arkansas and some other States have been able to enter into a partnership in advancing science.

Thank you for the opportunity of making these remarks.

[The prepared statement of Mr. Costello follows:]

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[1]The EPSCOR program funded by the National Science Foundation.

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COMMITTEE ON SCIENCE SPACE AND TECHNOLOGY

SUBCOMMITTEE ON SCIENCE

ROLE OF BASIC RESEARCH IN ECONOMIC COMPETITIVENESS

JUNE 20, 1991

Mr. Chairman, I want to thank you for gathering us here today to listen to testimony on the role of basic research in economic competitiveness.

The purpose of today's hearing is to asses the adequacy of federal basic research funding; examine various government university-industry partnerships; and examine whether universities are educating scientists, engineers, and technicians in sufficient numbers.

Mr. Chairman, I expect some interesting testimony from our witnesses. Thank you again for calling us together.

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Mr. BOUCHER. The Chair thanks the gentleman, and welcomes now the first panel of witnesses: Dr. Erich Bloch, who is Distinguished Fellow of the Council on Competitiveness in Washington and former Director of the National Science Foundation. We are very pleased to have you this morning. Dr. Straub is also with us, and I would again yield to the gentleman from Arkansas for the purpose of an introduction of Dr. Straub.

Mr. THORNTON. Well, Dr. Straub was the person in Arkansas who John Talmadge contacted with regard to Arkansas' interest in being an initial EPSCOR State. Since that time he assisted in forming the first quasi-public authority in the United States, patented after the New York Port Authority, as the Arkansas Science and Technology Authority, funded by the State with the capability of promoting pure research.

Dr. Straub is now the head of the EPSCOR program in Arkansas, is a member of the Science and Technology Authority, and does all of this in his spare time, because his employment is as a scientist, doctor, for the Veterans Administration Hospital in Little Rock. And, as a volunteer, he has had a tremendous impact upon our State and I am honored to have the privilege of introducing him today.

Mr. BOUCHER. Thank you very much, Mr. Thornton. And, Dr. Straub, we welcome you to the subcommittee this morning.

We are also expecting Dr. Peter Likins, who is President of Lehigh University. I am told that he is involved in a conference telephone call at the moment and should be joining us shortly.

Let's begin this morning with you, Mr. Bloch. Without objection, your statement as well as that of the others will be made a part of the record, and we'll be pleased to receive your oral summary.

STATEMENTS OF ERICH BLOCH, DISTINGUISHED FELLOW, COUNCIL ON COMPETITIVENESS, WASHINGTON, D.C.; PETER LIKINS, PH.D., PRESIDENT, LEHIGH UNIVERSITY, BETHLEHEM, PENNSYLVANIA; DAVID STRAUB, M.D., ASSOCIATE CHIEF OF STAFF FOR RESEARCH, THE VETERANS ADMINISTRATION MEDICAL CENTER, LITTLE ROCK, ARKANSAS

Mr. BLOCH. Thank you, Mr. Chairman. I appreciate the opportunity to testify on a very important question, the connection between science and economic competitiveness. There are many reasons why science research and economic competitiveness are linked. The emergency of a global economy has increased economic competition throughout the world. In the years following World War II the U.S. enjoyed a dominant position in nearly all technologies. Today, that is no longer true.

It is the judgment of the Council on Competitiveness report, "Gaining New Ground," that the U.S. position, and I quote, "in many critical technologies is slipping and, in some cases, has been lost altogether. Future trends are not encouraging."

Equally important, this global economy is a knowledge-based and a skill-based economy. A nation's competitiveness is not so much determined by natural resources, but the crucial factors today include the generation, the access, and the rapid deployment of new

knowledge and technical insights and the ability to convert them into quality processes and marketable products.

In this new environment, the importance of science—and let me hasten to add—technology, and our standing in these two areas is of paramount importance to our competitive standing in the world.

There is a general consensus, and you, Mr. Chairman, have made that point before, that we do not lag behind our competitors in science and basic research. You said our universities are the envy of the world, and that is absolutely correct. But we are trailing badly in our ability to translate basic research results and insights into commercial products.

One of the reasons for this problem is the artificial boundaries that we place between science and technology. Science and technology are a continuum. The interaction between them is complex, not sequential, moving back and forth between the two. One influences the other. That artificial boundary finds its expression in our public policies, where the government's role in science and basic research is judged to be appropriate and proper, but the role of government in generic technology must stand the litmus test of political beliefs, more often than not. Those same boundaries are also present in industry and academia, I should add, leading to cumbersome organizations with inordinate cost and product delays in industry and a value system in academia that inhibits our brightest students from aspiring to careers in manufacturing or product design over those in research.

Government, industry and academia must deal with the country's declining ability to compete. First, the Federal Government must establish and implement a technology policy that parallels the long established and well understood science policy. And, in my written submission I am quoting, essentially, the U.S. Technology Policy report which was issued last year. This policy, as stated in that report, encourages the creation of coalitions between government at the Federal, State and local levels as well as industry and universities to work jointly in this important area. We will have taken a major step forward in enhancing the competitiveness of the country.

Our technology policy should also include partial government funding, for the same rationale that justifies government funding for basic science. These efforts are expensive. They have a long gestation period. They diffuse quickly to competitors, and by the way, our international competitors, foreign governments, are funding their efforts in their countries as well.

We need not spend further efforts on identifying critical technologies. That has been done too many times. There are many reports laying on the table. They all say the same things. But the reports also point out that this is the time for action.

I want to acknowledge that some action has been taken in the 1992 budget and in the years preceding it, and the Engineering Research Centers are just one of these examples. Let me just say one thing about the Centers. I'm sure you'll hear some more about it in the second panel, and maybe even in this panel here.

I think there is only one test that one can apply to see the effectiveness of these Centers, and that is the market test. How much

participation is there by industry? That is the only test that I would suggest that is of value.

And I must say we all have been surprised at the participation from industry. There are about 1800 industry people that at one time or another have interacted with the Centers. Industry itself, together with the States, has spent as much money on these Centers as the Federal Government has, and I would say that gives us an idea that the Centers are hitting the mark.

A second cooperative effort that I want to highlight is SEMATECH. It's another example of a joint effort that merits attention, and, by the way, continued support, as their funding runs out next year. It's a consortium of 14 U.S. semiconductor manufacturers that was formed 2 years ago in partnership with the Department of Defense and is determined to help the U.S. achieve global leadership in chip-making technology.

I just want to say one thing on that. We need to show some patience. Three years is not enough for an undertaking of that sort to have visible kinds of results.

The third area that I want to highlight comes from the 1992 budget, which for the first time requests funding for the High Performance Computing and Communications Initiative. This initiative is important in a number of respects. First of all, it focuses on information and communication technology, which is one of the critical technologies that everybody identifies as of importance. Secondly, it is an initiative among all departments and agencies of the Federal Government that have a responsibility in this area. And thirdly, because of its cohesive plan and activities as spelled out in the 1992 budget it is visible to industry and permits industry to access the activities and results, and mount even companion projects to those of the government or collaborate in the government effort.

While it is industry's task and responsibility to identify, select and commercialize the technologies that it deems important to competitiveness, government and academia can be partners at the precompetitive stage.

The '92 budget for R&D is $72 billion, or a 13 percent increase over 1991. The question of adequacy of that budget comes up from time to time, but I don't want to address that. What is more germaine, in my opinion, is the question of how well we are spending what Congress will finally allocate.

I have been a critic of both our priority-setting process as well as the priority decisions that we are making. Let me just summarize my views.

We need to rebalance the R&D budget between defense and civilian R&D. We are spending too much on defense, because reduction in the tension between the U.S. and the Soviet Union really should be in our favor to make that happen. Secondly, is the fact that technology is developed and used today in the civilian content first, rather than in the military one, means that we need to focus more on civilian technology.

We need to prioritize our R&D effort, and I would suggest three categories of prioritizations. The first one, enhancing science and basic research and its infrastructure. Secondly, enhancing econom-

ic competitiveness; third, enhancing government mission and U.S. prestige.

The reasons are self-evidence. If our infrastructure is deficient, the other two areas will not be able to overcome this very severe handicap. If our competitiveness continues to decline, our security is jeopardized, as much or more than if we were neglecting the defense of the country, and we will not be able to afford the needed investment in many of our social areas like education, research, and our institutions.

Finally, if we invest in prestige projects and neglect the basic infrastructure or don't educate or attract the people who can design and utilize these projects, the benefits from these projects will be highly questionable.

Congress, and this committee in particular, can be instrumental in setting the country on the right course. Congress can give the U.S. science and technology policy a properly balanced set of activities. The initiatives I cited before, while not exclusive, are certainly candidates for your consideration and that of the administration.

A second area that Congress needs to address is the way it deals with the total R&D budget. The congressional budgetary process is split among 13 appropriations subcommittees and R&D is distributed among 9 of them. This makes it nearly impossible to set priorities among competing programs, consider any R&D program in a comprehensive manner, or make trade-offs among like activities.

To lessen this problem, Congress should create an oversight committee of the committee chairs of both houses that have jurisdiction over part of the R&D budget and conduct a yearly policy and priority review that sets priorities in place for the individual committees to follow.

Mr. Chairman, we are facing an increasing competitive challenge in the 1990s. Strong and sustained public investments in education and research are critical components of any successful strategy to promote economic growth and improve our competitiveness. We have to assure that our public policy considers both science and technology, that we achieve a more proper balance between defense and civilian R&D, and that we develop more cohesive initiatives in the areas of critical science and technology.

Congress needs to implement a process that allows priority-setting because our budgetary resources will be constrained for a long time, but the competition we encounter will only increase.

Thank you very much.

[The prepared statement of Mr. Bloch follows:]

Council on Competitiveness

ERICH BLOCH

DISTINGUISHED FELLOW, COUNCIL ON COMPETITIVENESS

TESTIMONY

HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

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JUNE 20, 1991

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TESTIMONY

HOUSE COMMITTEE ON SCIENCE, SPACE AND TECHNOLOGY

SUBCOMMITTEE ON SCIENCE

JUNE 20, 1991

Mr. Chairman, I appreciate the opportunity to testify before this Committee. As Director of the National Science Foundation (NSF), I testified before this Committee many times in the past. Today I welcome the opportunity to testify on the connection between science and economic competitiveness, a subject that was of concern to me in my previous position, and is, from my current vantage point, as a member of the privately funded Council on Competitivenes, an even greater concern.

Let me say at the outset that the question you are focussing on today would not have been at the center of concern only a decade ago. Today it is, and rightly so.

There are many reasons why science research and economic leadership should be linked:

o The emergence of a global economy has brought increased economic competition as other nations have built up their capabilities in science, engineering and technology. The change from a national economy to a global one has challenged American leadership. In the years following World War II, the U.S. enjoyed a dominant position in nearly all technologies. Today that is no longer true as we face a challenge on many fronts. In fact, it is the judgment of the Council on Competitiveness report, "Gaining New Ground," that

> "The U.S. position in many critical technologies is slipping and, in some cases, has been lost altogether. Future trends are not encouraging."

o Equally important, this global economy is a knowledge-based, skill-based economy. A nation's competitiveness is not so much determined by natural resources, access to low-cost labor and other classical, comparative advantages of the past. Now crucial factors include the generation, access and rapid deployment of new knowledge and technical insights and the ability to convert them into quality processes and marketable products.

In this new, global environment, the importance of science--and let me hasten to add--technology, and our standing in these two areas is of paramount importance to our competitive standing in the world.

The Continuum of Science and Technology

The rapid developments in the sciences, technology and product areas makes it increasingly inappropriate to divide the disciplines of science and technology as if they were unrelated.

Science and technology are a continuum. The interaction between them is complex and not sequential, moving back and forth between the two. No doubt, there are many cases where the output of science was the impetus to technology. But the reverse is also true--developments in technologies provide understanding, insight, and focus to the sciences.

There is a general consensus that the U.S. does not lag behind its competitors in science and basic research accomplishments, but we are trailing badly in our ability to translate basic research results and insights into commercial products.

One of the reasons for this problem are the artificial boundaries that we place between science and technology and also, let me add, between technology and manufacturing. That artificial boundary finds its expression in our public policies where the government's role in science and basic research is judged to be appropriate and proper, but the role of government in generic technology must stand the lithmus test of political beliefs. Those same boundaries are also present in industry where the

compartmentation between science, technology and manufacturing lead to cumbersome organizations with inordinate cost and product delays, and a value system that inhibits our brightest students from aspiring to careers in manufacturing or product design over those in research.

A New Policy Framework and Cooperation

Just as industry must deal with its declining ability to compete, Government must deal with the competitive problem of the country as a whole.

First the federal government must establish and implement a technology policy that parallels the long-established and well understood science policy. The document "U.S. Technology Policy" issued last year by the Office of Science and Technology Policy (OSTP) was a good start. Of particular note is the strategy of

> "...participating with the private sector in precompetitive research on generic, enabling technologies that have the potential to contribute to a broad range of government and commercial applications."

If this approach encourages the creation of coalitions between government at the federal, state and local levels, as well as industry and universities, to work jointly in this important

area, we will have taken a major step forward in enhancing the competitiveness of this country.

Better relations between industry and universities yield benefits to both sectors. Universities get needed financial support and a better vantage point for understanding industry's needs. Industries get swift access to the best new ideas and the brightest people. Furthermore, industry-university collaboration enhances training of the nation's future scientists and engineers in areas relevant to industry's needs. Government brings its financial and technical resources into closer contact with the realities of the marketplace.

Joint undertakings between industrial firms is another important component of cooperation. In the past, antitrust laws forced companies to consider competitors as adversaries. This worked well when competition was largely domestic. But today those barriers are less effective because competition is increasingly taking place on a world market scale, not on a national one.

Our technology policy should also include partial government funding, when costs are prohibitive for the private sector to fund by itself, or our technology base is completely lacking. In addition the same rational that justifies government funding for basic science also apply to generic technologies: they are expensive, they have a long gestation period, and they diffuse

quickly to competitors. More often than not, these technologies serve a number of different sectors, and foreign governments strengthen their technological base through public funding.

Implementing a U.S. Technology Policy

We need not spend further efforts on identifying critical technologies. All the reports released over the last two years, point to the same general generic technology areas: such as information and computing technologies, materials technology, and biotechnology. What these reports also point out is the need for action. I want to acknowledge that some action has been taken in the 1992 budget and in the years preceeding it. Let me cite three areas that I consider important and different from each other.

(a) Engineering Research Centers (ERCs)

Engineering Research Centers focus major cross-disciplinary programs of research on engineering systems important for competitiveness. They have been established to work in close collaboration with industry to improve industrial input into research programs, and to speed the transfer of knowledge into engineering systems important for industry. In addition to their research focus, the ERCs have major educational programs designed to improve and update the teaching of engineering in universities.

ERCs are supported by NSF and industry, along with some state funding and support from their home universities. In general, NSF's support is doubled through these other sources. There are currently some 700 industrial memberships by some 400 firms in the current set of nineteen ERCs.

A large number of industryial professionals have spent extended time on campus with 68% continuing to collaborate when they returned to their companies, while thirty-one percent reported an impact on new product development, including a new, environmentally compatable plastic, the first new product clearly based on a cooperative effort.

(b) SEMATECH

This is another example of a joint effort that merits attention and continued support. This consortium of fourteen U.S. semiconductor manufacturers was formed two years ago in partnership with the Department of Defense, and is determined to help the U.S. achieve global leadership in chipmaking technology. SEMATCH is not without its critics. But the 1990 report to Congress from the Advisory Council charged with assessing the consortium's progress, recommended continued government support and funding. The report states that:

"(SEMATECH) has translated its mission into operating programs that are responsive to market forces and....it can point to an extensive inventory of important projects underway. It is

reshaping relationships between U.S. chipmakers and their suppliers. And it has spurred new interest in cooperative research in industry, government, and academe."

(c) Budget Initiatives

The 1992 budget for the first time requests funding for the High Performance Computing and Communications Initiative (HPCCI). This initiative is important in three respects. First because of its focus as an information and communication technology. Second, because it is an initiative among all departments and agencies of the federal government that have a responsibility in this area. Third, because of its cohesive plan and activities, it is visible to industry, and permits industry to access the activities and results in an easier way and even mount companion projects to those of the government or collaborate in the government effort. The industry funded and organized Computer Systems Policy Project (CSPP) consisting of eight major computer companies is considering its relationships to this initiative.

Other examples of science and technology areas that should be given similar treatment are materials technology, biotechnology and manufacturing technology.

These examples demonstrate that it is industry's task and responsibility to identify, select and commercialize the

technologies that it deems important to competitiveness, but government and academia can be partners at the pre-competitive stage.

Collaboration between industry, academia and government can be greater than the sum of individual effort, because the result can spill over into activities like education, and be a focus of technology transfer and distribute other nonproprietary information not easily transmitted or captured, like the state of the art of measurement or quality.

More cohesive focus among the agencies of the federal government,such as in the HPCCI initiative, will result in a more cohesive program and can serve as an invitation to industry to participate in the program's planning and execution and can act as a stimulus for industry's own program to better exploit the federal R&D effort.

Adequacy of Federal R&D Funding and Priorities

The FY92 budget request for R&D is $72 billion, or a 13% increase over 1991. The question of adequacy is not what I want to address. What is more germaine is the question of how well we are spending what Congress will allocate.

I have been a critic of both our priority setting process as well as the priority decisions we are making. Let me just summarize my views.

We need to rebalance the R&D budget between defense and civilian R&D. The reason is clear: With the reduction in tension between the two main adversaries, our R&D spending for military purposes should decrease. A second and more important reason is the fact that technology is developed and used today in the civilian context first, rather than in the military one, which was the case in the past.

We need to prioritize the major reasons for supporting R&D, and be precise in our judgment as to which programs belong to each category. The categories and the priorities I would suggest are:

o Enhancing science and basic research and its infrastructure;

o Enhancing economic competitiveness;

o Enhancing government mission and U.S. prestige.

The reasons are self-evident: If our infrastructure such as education, facilities, universities, the quality and quantity of scientists and engineers in the country are deficient, the other two areas will not be able to overcome this severe handicap.

If our competitiveness continues to decline, our security is jeopardized, as much or more than if we were neglecting the defense of the country, and we will not be able to afford the needed investment in many of our social areas like education, reseach and our institutions.

Finally, if we invest in prestige projects and neglect the basic infrastructure or don't educate or attract the people who can design and utilize these projects, the benefits from these projects will be questionable.

The Role of Congress

Congress, and this committee in particular, can be instrumental in setting the country on the right course.

Congress can give the U.S. science and technology policy a properly balanced set of activities. The initiatives I cited before, while not exclusive, are certainly candidates for your consideration and that of the Administration.

A second area that Congress needs to address is the way it deals with the total R&D budget.

Because the congressional budgetary process is split among thirteen appropriations subcommittees in both the House and the Senate, with R&D distributed among nine of them, this split can make it nearly impossible to set priorities among competing programs, consider any R&D program in a comprehensive manner, or make trade-offs among like activities.

It is not in the cards for Congress to concentrate the R&D budget in one Committee. However, Congress could create an oversight Committee consisting of the committee chairs of both Houses that have jurisdiction over part of the R&D budget and conduct a yearly policy and priority review that sets priorities in place for the individual committees to follow.

Summary

America is facing a global competitive challenge in the 1990s, and not just from the Pacific Rim. The consolidation of our Western European allies into the European Economic Community (EEC) adds yet another tough contender in the race for global economic leadership.

Strong and sustained public investments in education and research are critical components of any successful strategy to promote economic growth.

Congress has the responsibility to assure that our public policy considers both science and technology, that we achieve a more proper balance between defense and civilian R&D, and that we develop more cohesive initiatives in the areas of critical science and technology.

Congress needs to implement a process that allows priority setting because our budgetary resources will be constrained for a long time, but the competition we encounter will only increase.

I thank you for this opportunity to testify and I will be happy to answer any questions that you may have.

Mr. BOUCHER. Thank you very much, Mr. Bloch. We will have questions of you momentarily. Prior to that, however, let's hear from our other two witnesses.

Dr. Straub, at this time we would be pleased to receive your statement.

Dr. STRAUB. Mr. Chairman, members of the committee, I thank you for inviting me here to discuss and testify as part of this panel on the role of basic research in economic competitiveness. Although I am a full-time employee of the Department of Veterans Affairs, I am here as a private citizen, and none of my testimony is endorsed by the Department of Veteran Affairs. My remarks will concern the role of the States, particularly Arkansas, in leveraging Federal funds and developing strategies to maximize the effectiveness of basic research in stimulating economic competitiveness. This is in the context of a broader discussion on the effectiveness of the current mechanisms to stimulate university-industry partnerships.

I should now like to describe to this committee a statewide agency, the Arkansas Science and Technology Authority, which I'll call ASTA, which was established for the support of science and technology in Arkansas with the goal of advancing the economy of the State.

As Mr. Thornton has pointed out, ASTA actually had its beginnings in hearings before this committee in the late '70s under the circumstances which you heard, when the NSF was persuaded to assist the very bottom States in performance of basic research. The NSF developed the EPSCoR program, with which this committee is familiar. Arkansas was one of the first States which succeeded in the initial competition for a 5-year grant to make scientists of the State more competitive for Federal funds. The program was established and directed by a statewide ad hoc committee of which I was a member and am now chairman.

Very soon after the beginning of the funding for the EPSCoR program the committee realized that the State needed a life after EPSCoR which would carry on the statewide initiative to support and encourage our scientists after the 5 years of Federal funding had run its course.

The discussions concerning this "life after EPSCoR" soon grew into a task force which developed the initial plan and legislation for a statewide authority to support science and technology patterned on the legislation which established the New York Port Authority. In 1983, thanks to the hard work of members of the task force, the legislators, the Governor's office, Act 859 of the General Assembly created the Arkansas Science and Technology Authority, which has as its mission "to gain the benefits of advanced science and technology for the people of Arkansas" I must point out that this was presaged by a long discussion in the legislature, also prompted by support from the NSF in the old Science Information Liaison Office, which was carried on in our legislature and is still existent.

The Authority was allowed to make contracts, to acquire and dispose of real estate, enter into agreements, invest funds, borrow money, accept grants and donations, trade securities, finance and conduct investigations, prepare and publish technological studies

and reports, organize and conduct conferences, own patents, provide scientific and technological data and information, study and develop plans and programs in science and technology, support industrial development, and recommend legislation and issue revenue bonds. Since then the revenue bond authority has gone to another agency.

This was one of the first statewide authorities of its kind in the United States. And with the broad mandate and flexibility to support its programs in many different ways, ASTA has been appropriated money and authority to establish a number of programs which are described in detail in the appendix to this written testimony and which are mentioned briefly here: Number one is the seed capital investment program; number two, a business incubator program; number three, a technology transfer program; number four, a basic and applied grants program; number five, a small business innovative research program; number six, Centers for Applied Technology program; and, number seven, a technology development program.

Of particular interest here is the basic and applied research grants program, and you have an accompanying chart which indicates that this program has received 356 applications and has funded 98 proposals for a total of slightly over $3 million since 1987.

The research projects are solicited on a statewide basis and are judged on scientific merit and economic impact by both outside and in State reviewers. Only meritorious projects are funded, but all applications are reviewed and the scientists receive the reviewers' comments in order to improve the quality of their proposals.

This program has not only been responsible for some outstanding successes with direct economic impact, but it has also been responsible for bringing in State research funding as well—out-of-State research funding as well.

I would just like to in my oral testimony give you some ideas about some specifics. For instance, we had a spinach blight in our State, and the spinach industry is small but employs a number of people. One of our scientists at the University of Arkansas said he knew how to solve the problem, if he could get some money from the Authority. He received some money from the Authority. In one growing season, he established a new strain of spinach, which subsequently was resistant to the disease, and now the spinach industry, which would have left the State, is very healthy indeed.

One of our professors at the university had a very important instrument for electron diffraction that he was unable to get funding for. He was funded through this Authority and the EPSCOR program, and his instrument was voted one of the top industrial instruments in the country in, I think it was 1985.

I don't want to belabor you with the number of successes, but we have a number and they are included in the appendices to this testimony.

Now, in the first two rounds of funding we leveraged a considerable amount of money from out-of-State sources for the investment of $1.7 million in State support, about $4.3 million in follow-on funding from Federal and private sources was received by scientists

in our State, and those details are included in a separate appendix in the written testimony.

In addition, the staff—ASTA staff and the Board of Directors are assuming a very important role of long range planning for State support of science and technology, and in the accompanying appendix you will see the 1991 to '93 biennial plan by this Board, which I think indicates the broad view and vision of the State Science Authority, of which I am proud. And I didn't have anything to do with the writing of this biennial report, so I can brag on it.

During the initial long range planning the Board of Directors and advisory committees were alarmed at the lack of communication between State and Federal agencies responsible for encouraging and supporting science and technology. As you know, the traditional mechanisms of funding, and therefore the lines of communication, have been established through direct support of individual scientists within the university or consortium by the Federal Government. There are very few formal or informal paths of communication between State government and Federal agencies responsible for science and technology.

As the world is becoming a much closer community because of rapid advances in communication and transportation, advances in science and technology are crossing all boundaries, whether they are disciplinary boundaries or State or national borders. It seems urgent that the State governments and the Federal agencies form some partnership which can support the science and technology base and assist the university-government collaboration with the industry which is necessary for a healthy economy. The success of our NSF/EPSCoR/ASTA partnership I think provides a good model for such science and technology partnerships.

Within the time allotted me I can't provide details of the important lessons we have learned during the establishment and operation of ASTA, but I would offer some conclusions:

Number one, the States do have a very important role to play in the support of science and technology. Strong advocates for science and technology in the legislative and administrative levels of State government are necessary. Good leadership within the State science and technology agency is necessary once it is established. And Federal collaboration is essential. Funding of the agency must be based on meritorious science, number one, and also on economic impact in order for it to get political support. A hands-on attitude by the agency to promote collaboration between universities and industries and which fosters grass-roots scientists getting together to attack a problem is essential. I really am worried about bureaucracies which have in them no scientists and who really search databases and give advice without scientific input. Statewide solicitation of proposals in an objective manner is critical to maintain a statewide political balance. Everybody has to be treated fairly in the State and awards of funding have to be given on the same fair basis. There needs to be a continuing and intense analysis of the programs these agencies put forward and by both internal and external sources.

Since the States provide over $1 for every $8 of Federal money in basic research, the States have a legitimate role as a partner with the Federal Government.

It is safe to say that without initial NSF involvement ASTA would not exist. There is a critical role of Federal Government in getting such endeavors started and in developing partnerships with the Federal Government which sets the national agenda for science and technology.

There are unresolved problems of which Federal agencies should be responsible for in these State-Federal partnerships. What agency should do it? If you are interested in the health of science, the NSF is the perfect place. If you're interested in economic advancement, I don't know. I think NSF may be. But that is a deliberation that must be carried on. Perhaps some experimental programs to stimulate different State initiatives would be in order since various States have various needs and they all are not met by a statewide agency probably.

Now, while I have spoken mostly of statewide science and technology support effort in Arkansas and made some point of the State-Federal partnership, it is likely that the truly satisfactory solution must be a partnership amongst all the participants, the Federal Government, the State government, industry, and universities. This will require removal of some barriers to partnerships, maybe tax and corporate law revisions, changes in charters of the universities, changes in charters of the state agencies. But I think no less than the continuing nationwide attention to forging this important partnership will do. It is essential that the grass-roots scientists and engineers who do the work have as few layers of bureaucracy as possible as they establish their cooperative efforts.

Thank you.

[The prepared statement of Dr. Straub follows: See Appendix starting on p. 116 for additional attachments.]

STATEMENT BY

DR. DAVID STRAUB

BEFORE THE SUBCOMMITTEE ON SCIENCE
ON THE ROLE
OF BASIC RESEARCH IN ECONOMIC COMPETITIVENESS
June 20, 1991

Mr. Chairman, members of the committee, thank you for inviting me here before the Congress to testify as part of this panel on the role of basic research in economic competitiveness. Although I am a full time employee of the Department of Veterans Affairs, I am here as a private citizen and none of my testimony is endorsed by the Department of Veteran Affairs. My remarks will concern the role of the states, particularly Arkansas in leveraging federal funds and developing strategies to maximize the effectiveness of basic research in stimulating economic competitiveness. This in the context of a broader discussion on the effectiveness of the current mechanisms to stimulate university-industry partnerships..

I should like to describe to the committee a state-wide agency, the Arkansas Science & Technology Authority (ASTA), which was established for the support of science and technology in Arkansas with the goal of advancing the economy of the state.

ASTA actually had its beginnings in hearings before this committee in the late 1970's when the National Science Foundation (NSF) was persuaded to assist the very bottom states in performance of basic research. The NSF developed the EPSCoR program with which this committee is familiar. Arkansas was one of the first states which succeeded in the initial competition for a five year grant to make scientists of the state more competitive for federal funds. The

program was established and directed by a state-wide ad hoc committee of which I was a member and am now chairman.

Very soon after the beginning of funding for the EPSCoR program the committee realized that the state needed a "life-after-EPSCoR" which would carry on the state-wide initiative to support and encourage our scientists after the five-years of funds had run its course.

Those discussions soon grew into a task force which developed the initial plan and legislation for a state-wide authority to support science and technology patterned on the legislation which established the New York Port Authority. In 1983, thanks to the hard work of members of the task force, legislators, and the Governor's office, Act 859 of the General Assembly created the Arkansas Science & Technology Authority which had as its mission to "gain the benefits of advanced science and technology for the people of Arkansas". The Authority was allowed to make contracts, acquire and dispose of real estate, enter into agreements, invest funds, borrow money, accept grants and donations, trade securities, finance and conduct investigations, prepare and publish technological studies and reports, organize and conduct conferences, own patents, provide scientific and technological data and information, study and develop plans and programs in science and technology, support industrial development, recommend legislation and issue revenue bonds,(revenue bond authority has since been

transferred to another agency). This was one of the first state-wide authorities of its kind in the United States With the broad mandate and flexibility to support its programs in many different ways ASTA has been appropriated money and authority to establish a number of programs which are described in detail in the appendix to this testimony and which are mentioned briefly here;

1. Seed capital investment program,
2. Business incubator program,
3. Technology transfer programs,
4. Basic and applied grants program,
5. Small business innovative research program,
6. Centers for Applied Technology Program, and
7. Technology development Program.

Of particular interest here is the basic and applied research grants program. As can be seen in the accompanying table this program has received 356 applications and funded 98 proposals for a total of slightly over $3 million since 1987. The research projects are solicited on a state-wide basis and are judged on scientific merit and economic impact by both outside and in state reviewers. Only meritorious projects are funded, but all applications are reviewed and the scientists receive the reviewers' comments in order to help improve the quality of their proposals. This program has not only been responsible for some outstanding success with direct economic impact, it has been responsible for bringing in non-state research funding as well. In the

first two rounds of funding approximately $1.7 million in state support resulted in $4.3 million in follow-on funding from federal and private sources. Details of this program are included as a second appendix to this testimony.

The ASTA staff and Board of Directors are assuming a very important role of long range planning for state support of science and technology. The first accompanying appendix includes such plans for the 1991-1993 biennium for Arkansas.

During the initial long range planning the board of directors and the advisory committee were alarmed at the lack of communication between the state and federal agencies responsible for encouraging and supporting science and technology. The traditional mechanisms of funding and therefore the lines of communication have been established through direct support of the individual scientists within the university or consortium by the federal government. There are very few formal or informal paths of communication between the state government and federal agencies responsible for science and technology. As the world is becoming a much closer community because of rapid advances in communication and transportation, advances in science and technology are crossing all boundaries, whether they are disciplinary borders or state or national borders. It seems urgent that the state government and federal agencies form partnership which can support the science and technology base and to assist the university-government-industry collaboration necessary for a hearty economy. The success

of NSF EPSCoR and ASTA in forming such a partnership and support for science and technology on a state wide basis makes it a good model.

Within the time allotted me I cannot provide details of the important lessons we have learned during the establishment and operation of ASTA, but some conclusions are possible:

(1.) The States have a very important role to play in support of science and technology programs;

(2.) Strong advocates for science and technology in the legislative and administrative levels of state government are necessary;

(3.) Good leadership within the state science and technology agency is necessary;

(4.) Federal collaboration is essential;

(5.) Funding of the agency must be based on meritorious science and economic impact;

(6.) Hands on attitude of the agency to promote collaboration between universities and industry and which fosters grass-roots scientists getting together to attack a problem is essential;

(7.) State-wide objective solicitation of proposals and awards of funding is extremely important;

(8.) There needs to be a continuing and intense analysis of the progress of the agency and its mission by both internal and external sources.

Since the states provide over one dollar for every eight dollars federal money for basic research, the states have a legitimate role as a partner with the federal government.

It is safe to say that without the initial NSF involvement ASTA would not exist today. There is a critical role of federal government in getting such endeavors started and in developing a partnership in which the federal government sets a national agenda for science and technology.

There are unresolved problems of which federal agencies should be responsible for in these state-federal partnerships. In addition, what works for one state may not work for another; thus there will almost certainly be several good mechanisms for states to develop their scientific and technological base in support of economic advancement. Perhaps some experimental programs to stimulate different state-wide initiatives supported in part by the federal government may be in order.

While I have spoken mostly of a state-wide science and technology support effort in Arkansas and have made the point of state-federal partnership, it is likely that a truly satisfactory solution must be a partnership among all the participants, federal government, state government, industry, and universities. This will require the removal of many barriers to such partnerships including revision of tax and corporate law, and changes in charters of universities

and state agencies. No less than continuing nationwide attention to forging this important partnership will do. And it is essential that the grass roots scientists and engineers who do the work have as few layers of bureaucracy as possible as they establish their cooperative efforts.

RESEARCH GRANT PROPOSALS

	86-87	88-89	90-91	TOTAL
Basic Proposals Submitted	138	59	104	301
Basic Proposals Funded	18	20	29	67
Applied Proposals Submitted	11	32	12	55
Applied Proposals Funded	7	17	7	31
Dollars	$868,229	$824,180	$1,075,161	
Energy		$243,672	$77,155	
				$3,088,397

FIGURE I

6/91

Mr. BOUCHER. Thank you very much, Dr. Straub.

The Chair at this time would recognize our colleague from Pennsylvania, Mr. Ritter, for the purposes of introducing Dr. Likins.

Mr. RITTER. Thanks very much, Mr. Chairman. And I want to thank you and the ranking member for holding this hearing, and for your leadership. We have worked closely together and I know we share a lot of common grounds. I'd like to associate myself with your opening remarks, Mr. Chairman. I think they are right on target.

A quick comment. As someone who has been interested in the redirection of the Federal R&D economy to more closely align itself with the needs of America's global competitors faced with the daily battles and the daily challenges, I think this hearing is an important step towards at least exposing some of the issues that we deal with. I think to some extent the Federal R&D economy has been responsible for directing the minds and the Ph.Ds. of our best and brightest away from problems and challenges and opportunities related to the private sector. And I think there is some obligation to come back to the fold now that we do have competitors out there, and the rest of the world isn't just rubble or rubble plus rebuilding.

Well, without further ado, I'd like to introduce the president of Lehigh University and my good friend, Dr. Peter Likins. Dr. Likins, as far as I'm concerned, is a man for all seasons, and I am so delighted that he has chosen to share his insights with us today. He is a member, as many of you know, of the President's Council for Advise on Science and Technology. He is a member of the National Academy of Engineering. He is a former dean and provost of Columbia University. He has his degrees from Stanford and M.I.T.

At Lehigh, he has provided the university with a quantum leap into the kind of future that I think we're trying to define here, in bringing Lehigh's research and development and faculty and their science base towards addressing these challenges. The new mountain-top campus was dedicated a couple of weeks ago. Lee Iacoccoa had a major role to play there. How times change. We went at Lehigh from the Homer Research Lab, which spanned across the top of South Mountain and a beautiful research campus as Bethlehem Steel contracted and changed and the world economy changed, this is now a Lehigh facility. And it is a cutting edge facility in a whole variety of areas that seek to contribute to global competitiveness, and the architect is before us here today. He had a little help from his friend Lee Iacoccoa, but he was a damn good architect.

So, without further ado, I'd like to introduce Dr. Peter Likins.

I also want to say hello to my good friend Erich Bloch, a witness par excellence, who on many, many occasions testified before this subcommittee.

So, thank you, Mr. Chairman. And I'd say that I wish I could be here, but as happens, occupational hazards as they are in being a member of this body—I am ranking on the Environment Subcommittee. We have a RCRA [Resource Conservation and Recovery Act], science and technology hearing. And I am also ranking on the Energy and Commerce subcommittee that is reauthorizing RCRA. So this is my day to learn about some of the technical dimensions of RCRA, and I will go and do so. And with apologies, Dr. Likins, Erich Bloch, Dr. Straub, I will take my leave.

Thank you, Mr. Chairman, for this opportunity.

Mr. BOUCHER. The Chair thanks the gentleman, and welcomes Dr. Likins.

Your prepared statement will be made a part of the record and we will be pleased to receive your oral summary.

Dr. LIKINS. Thank you, Mr. Chairman, and gentlemen of the subcommittee. I appreciate the opportunity to say a few words and to respond to questions. I promise to be brief, probably more brief than my friend Don Ritter.

Mr. RITTER. I've said it all.

[Laughter.]

Dr. LIKINS. I would not want to say the same words that Don's expressed, nor will I repeat the testimony of my colleagues here on this panel, although I share their views in many respects.

It has become customary to classify research spending in the United States as either basic or applied research. We also differentiate between defense research and nondefense research. These distinctions have proven useful in the past, but it may be more important in the future to distinguish between research that is targeted in fields with strong economic potential and research that is not economically targeted. The latter category includes research directed for other reasons, such as military potential, but it also includes research motivated merely by academic curiosity, by the human desire to understand.

In comparison with other nations of the world, the proportion of research in the United States that is economically targeted must be remarkably small, but the data are not represented in a revealing way and these statistics are not readily available. In comparison with Japan and Germany, our most successful partners in world trade, the data would tell a compelling tale. Among the many reasons for the comparative decline of the United States as an economic power in the world, certainly one reason is our research investment policy.

For almost 40 years after World War II, we operated with a de facto industrial policy that separated the affairs of government and commercial industry as rigorously as those of church and state, and increasingly drew universities into the orbit of government, as Congressman Ritter has mentioned a moment ago. We developed a research capability in American universities without precedent in world history, and financed academic research in the noncommercial fields of defense, space and health, or, in fact, any field that stimulated the imagination of a fine professor.

In those fields that received the benefit of decades of aggressive Federal funding, our research dominated the world scene. But for decades most American professors and their students had few incentives to work in fields of interest to commercial industry. There seemed to be a kind of an unstated ban on Federal sponsorship of economically targeted research, which was treated as the exclusive domain of industry.

Of course there are good reasons to engage industry in the determination of fields of inquiry with strong economic development potential. All these studies of critical technologies accomplish that objective. But research is not financed in industry unless the investor can capture any resulting benefits, and natural diffusion often

makes that outcome unlikely. Some kind of pooling of research resources is often required for the capture of benefits, and the various levels of government can either provide the necessary pooling through taxation or facilitate pooling through the development of partnerships, particularly involving consortia, including universities.

In this country, various State governments made commitments to economically targeted research before the Federal Government became deeply involved. The initiation of the Ben Franklin Partnership in Pennsylvania in the early '80s provides an early example. But the NSF entered this arena in the same time period with the first Engineering Research Centers and also the Industy-University Cooperative Research Centers. Other Federal agencies have followed suit in the course of the passing decade with various economically targeted partnership programs of their own.

In my opinion, these more recent initiatives of the past decade in the Federal Government are well conceived, and I've seen the right kinds of benefits in the form of industry participation, research results and educational experiences. In the long run, in fact, I value most deeply the educational benefits that flow to the Nation as a product of the new partnerships involving industry, universities, and government. Perhaps the next generation of engineers will better understand the importance of economic value in their work.

Thank you.

[The prepared statement of Dr. Likins follows:]

Testimony:	House Committee on Science, Space, and Technology
Date:	20 June 1991
Witness:	Dr. Peter Likins President, Lehigh University
Purpose of hearing:	To examine the role of government, universities, and industry in fostering basic research with strong economic potential.

It has become customary to classify research spending in the United States as either basic or applied research. We also differentiate between defense research and nondefense research. These distinctions have proven to be useful in the past, but it may be more important in the future to distinguish between research that is targeted in fields with strong economic potential and research that is not economically targeted. The latter category includes research directed for other reasons, such as military potential, and research motivated merely by academic curiosity, the human desire to understand.

In comparison with other nations of the world, the proportion of research in the United States that is economically targeted must be remarkably small, but the data are not presented in a revealing way. In comparison with Japan and Germany, our most successful partners in world trade, the data would tell a compelling tale of woe. Among the many reasons for the comparative decline of the United States as an economic power in the world, certainly one reason is our research investment policy.

For almost forty years after World War II, we operated with a de facto industrial policy that separated the affairs of government and commercial industry as rigorously as those of church and state, and increasingly drew universities into the orbit of government. We developed a research capability in American universities without precedent in world history, and financed academic research in the noncommercial fields of defense, space and health, or in any field that stimulated the imagination of a fine professor. In those fields that received the benefit of decades of aggressive federal funding, our research dominated the world scene. But for decades most American professors and their students had few incentives to work in fields of interest to commercial industry; there seemed to be an unstated ban on federal sponsorship of economically targeted research, which was treated as the exclusive domain of industry.

Of course there are good reasons to engage industry in the determination of fields of inquiry with strong economic development potential. But research is not financed in industry unless the investor can capture any resulting benefits, and natural diffusion often makes that outcome unlikely. Some kind of pooling of research resources is often required for the capture of benefits, and the various levels of government can either provide the necessary pooling through taxation or facilitate pooling through the development of partnerships, particularly with universities.

In this country, various state governments made commitments to economically targeted research before the federal government became deeply involved. The initiation of the Ben Franklin Partnership in Pennsylvania in 1983 provides an early example. But the National Science Foundation entered this arena in the same time period with the first Engineering Research Centers and the Industry-University Cooperative Research Centers; other federal agencies have followed with various economically targeted partnership programs of their own.

In my opinion, these more recent initiatives in the federal government are well conceived, and I've seen the right kinds of benefits in the form of research results and educational experiences. In the long run, I value most deeply the educational benefits that flow to the nation as a product of the new partnerships involving industry, universities, and government. Perhaps the next generation of engineers will understand the importance of economic value in their work.

Biographical Sketch

Peter Likins, President of Lehigh University in Bethlehem, Pennsylvania, was educated at Stanford (BS and PhD) and MIT (Master's degree), worked as a development engineer at the Caltech Jet Propulsion Laboratory in the early days of space exploration, and progressed through the faculty ranks at UCLA before moving to Columbia University as dean of engineering and later provost of the university. He has served Lehigh as president since 1982.

Likins is a member of the National Academy of Engineering, the executive committee of the Council on Competitiveness, Governor Casey's Economic Development Partnership Board, and President Bush's Council of Advisors on Science and Technology.

Mr. BOUCHER. Thank you very much, Dr. Likins. And the Chair expresses thanks to all of the witnesses who have appeared on this first panel for their very excellent testimony. Their comments are of great help to the subcommittee as it begins this inquiry.

Let me propound the very broad question to all of three witnesses in terms of the level of research funding in the United States in comparison with the level of research funding in our competitor nations, and let's use Japan and Germany as the examples. In those countries the level of research funding is approximately 3 percent of GNP on an annual basis. Now, by definition, that in both countries is almost exclusively civilian research. In the United States the amount of total research dollars every year spent for both civilian and defense purposes is about 2.6 percent of our GNP. We're only spending about 1.5 percent of GNP on civilian research alone. So, if you exclude the military component, whereas in Japan and West Germany the expenditure is about 3 percent of GNP, in the United States it's 1.5 percent. Now, obviously, there is some civilian commercial benefit to be obtained from the defense component of that expenditure. Not as direct, I think we all would concede, as the amount that is spent directly on civilian research.

Let me get the three of you to comment on the extent to which we should be concerned, if at all, about the disparity in research funding as a percentage of GNP in the United States and in those two competitor nations. Mr. Bloch, let's begin with you.

Mr. BLOCH. I think we should be very concerned about that. What you summarized essentially—is absolutely correct. The discrepancy at the civilian R&D level is very profound between us and the countries that you are citing. But I think it's even deeper than that, and let me try to make that particular point.

If you disaggregate even the civilian R&D or the total R&D into disciplinary work and also economic-competitiveness-related kind of work, you will see some very great discrepancies between us and the two countries that you are citing.

Let me just make one particular point, and I don't want to be misunderstood about it. If you look at what we are spending for life sciences, for instance, we are spending a great amount for that. The increases in the life sciences have been very great over the years. That is not the case in the physical sciences. Now life sciences are very important, important for health and important even for economic competitiveness. Think of the pharmaceutical industry. And no wonder that we are essentially doing pretty well in that particular field.

But, if you look at the physical sciences or at engineering, you will see essentially that as a percent of GNP we have leveled off for a long period of time, whereas Japan and Germany have increased their funding in those areas. So that is one way of looking at it.

The same situation, by the way, is also true, if you look at pure academic research, academic and government laboratory kind of research. You will see that Japan and West Germany spends much more effort on research that aims at engineering or that aims at the physical sciences than we do. In absolute dollars, by the way, if you look at the total European Community.

Let me make one other point. If you look at one particular field, namely computer—as the computer field, and you look at the R&D spending in computers, for instance, computers and information technology, we are spending about 2 percent and the total West European effort is about 23.9 percent of their total R&D spending. So very wide discrepancies in fields that are of economic competitiveness.

And I think we have to get away from looking strictly at the bottom line, but disaggregating the field.

Mr. BOUCHER. I gather that you're concerned about the fact that much of the increase in R&D spending in the U.S. in recent years has been directed in the life sciences field, not in the physical sciences field. We have, in part due to your leadership as Director of the NSF, established a course where we will double the budget of the NSF, which, of course, primarily engages in physical science research, over a 5-year period. In fact, the increase in the NSF's budget for FY '92 will be 17 percent, and we have an appropriations bill that has passed the House that contains that level of increase.

Is that enough? Are we doing what we should be doing in terms of the physical sciences by increasing the NSF's budget by that magnitude? Or should we be doing more? And, if we should be doing more, what steps should we be taking?

Mr. BLOCH. Well, first of all, let me remind you that we have been trying to double the NSF budget for a long period of time, for more than 5 years. So we have been delaying that funding. If that funding had occurred at the time when we all said—and this committee in particular, you know, in its authorization bill made that particular point. If we had followed that blueprint we would be in better shape today. There is no doubt in my mind.

The second thing I think, however, that we need to rectify is what I mentioned in my testimony and look at the total Federal R&D budget and see how that can be better spent in areas that Dr. Likins pointed out and in the areas that I pointed out. So it's really a rebalancing of the whole budget.

Yes, I would say we should spend more on physical sciences. No doubt about it. We should spend more on engineering. We should spend more on manufacturing technologies as a generic technology. We should spend more on biotechnology. We should spend more in all of these areas. High performance computing, we are spending quite a bit this year, but it's the first year, I want to remind you, where that is happening.

So a total look at the total budget I think is much more important than having an argument, do we need 2 percent more on the budget as a total. I think that argument is a good one to have, but I think a much more profound and far-reaching one is the balance within the budget itself.

Mr. BOUCHER. All right. Thank you. Dr. Likins?

Dr. LIKINS. Yes. I would like to associate myself with Erich Bloch's response, which in many ways reinforces with characteristic quantitative detail the message of my oral testimony.

Your question was phrased in terms of defense and nondefense spending as a—research spending—as a percentage of GNP, and the thrust of the question communicates a message with which I

agree. But it would be a much more powerful question if you could only find ways—if you could only find the data that would enable you to express it in terms of economically targeted research versus research that is not economically targeted. You'd find that some defense spending for research is economically targeted. Because those folks are getting the word too and they are putting money into research enterprises and manufacturing, for example, that clearly are designed to produce economic benefit. And you would find much of the research that is civilian or nondefense is not focused on this challenge of industrial competitiveness in the global economy, but it addresses a variety of different legitimate concerns. So, if the question could be reformulated, the message would be even more powerful.

Let me pick up Erich's observation about the life sciences versus the physical sciences, not to suggest that the comparative allocation of funds is inappropriate. I wouldn't presume to make that judgment. But I would suggest that the allocation of funds has been made on what I'll call ideological grounds, rather than responding pragmatically to the question, Where can the Nation best profit from investment in research?

The reason we have put money into the health sciences as into defense and space is because that has been somehow the province of government. And we have not made comparable investments in the physical sciences or in engineering because that is seen as somehow the province of industry. And it is that kind of ideological splitting of the two sets of interests, to which I take exception—if we could just pull back and rid ourselves of all of those, what some people may call philosophical bases for allocation, and simply address the practical questions—Where can we as a society best benefit from an investment in research?—then I think we would get a rather different distribution of monies. It certainly would produce a lesser distribution of monies into defense research; that is, research for strictly military purposes. Whether that takes money out of the Defense Department is a separate question. It does seem to me that in such areas as computing and communications, as evidenced by the High Performance Computing and Communications Initiative, there is enormous opportunity. We simply must find ways to make those investments.

But I submit that before we assume that the way to finance that initiative is through increasing the deficits or making predatory raids on the social services, I submit that we should first address the question, Are we utilizing our R&D monies most effectively? And I think if we go about that inquiry with a sufficiently balanced and, I submit, practical, pragmatic perspective that we would make substantial reallocations of money before we would be obliged to increase the monies.

Mr. BOUCHER. There has been something of a philosophical objection on the part of the administration all through the decade of the 1980s to investing Federal funds with a technology-specific goal in mind. We have seen funds invested in basic research but we haven't seen a lot of funding that is directed toward some commercial end or the development of a particular technology. Now there seems to be some shift in that focus on the part of the administration. OSTP is now—somewhat passively to my way of thinking—

but at least acknowledging that there is a role for the Federal Government in funding what I believe the Director of OSTP calls precompetitive technologies. Emphasis seems to be drifting now toward semiconductors, ceramics, and other kinds of materials. I think we would put the High Performance Computing Initiative aside because that is a little bit of a different question. Nonetheless, there seems to be some change in the administration's position with regard to whether we ought to be funding technology development.

What advice do the two of you who have responded so far have for the administration in this area in the future? Should there be a greater emphasis on funding precompetitive technologies? And if so, what specific advice would you offer? Mr. Bloch?

Mr. BLOCH. I would—the answer to your question is yes. Obviously, there should be more focus on it. And I think the approach taken with the High Performance Computing Initiative is a good model. It applies also to materials, for instance, materials science and materials processing.

Mr. BOUCHER. Next year?

Mr. BLOCH. Okay. Which is scheduled to appear in the 1993 budget. I hope it does. I think the same thing can be done, for instance, in manufacturing technologies. There is a cross-cut in the 1992 on manufacturing technology. But watch out. That is not the same thing as building up a program like the High Performance Computing one from the ground up. This is strictly a bureaucratic kind of an assembly of numbers that fall out of the various activities of the various agencies, and that is not the right approach. The right approach is to build it up from the bottom up and have the participation of all the agencies that have a role to play in it.

So, if over the years we can have five or six of these major activities spelled out in that way and maintained and continued, which is very important—one year is not good enough—then I think we are making a step forward. And I think Dr. Bromley deserves a lot of credit for pulling that together, for revitalizing the FCCSET [Federal Coordinating Council for Science, Engineering and Technology] Committee as a means of doing it. I would hope that he also would enlist and OMB would enlist the support and the help and the critique of industry in these efforts. Not after the fact, but when these programs take place. And that would be one of the suggestions of how to improve on it.

Mr. BOUCHER. Okay. Dr. Likins?

Dr. LIKINS. Mr. Chairman, I, with all respect, would suggest that we will get to the answers to these questions more expeditiously if we set aside the politics of the process. We have since World War II with a succession of administrations used much the same rhetoric and behaved much the same way in terms of our funding of research and development from Federal sources. Certainly in the administration that President Bush represents there is substantial concern expressed about focusing, about picking winners and establishing industrial policy. And you hear all those words and all those concerns expressed, and yet there is, in fact, more movement right now toward getting real and dealing with these problems than there has ever been. And, in my view, that's not a consequence of the Party in power. It is just that the American people

and the American Congress are finally—and the American executive branch are finally recognizing that realities are becoming compelling. We've got to do something.

So I hope that we can get past worrying about whether it is Republican policy or Democratic Party policy and just recognize that we've got a problem. And we are moving now to address those problems. Allan Bromley has been masterful in getting people in this town to focus—as Erich did earlier, I must say—to focus on these questions of industrial competitiveness.

The FCCSET Committee has brought all the agencies of the Federal Government into an acceptance of the notion of looking at these cross-cutting looks at the Federal budget. And, although that is only step one, as Erich says, that doesn't create money. That kind of rationalizes and integrates the budgetary description of monies to be spent for education or materials or manufacturing or computing. But that is a very important first step. It's just a rational step, nothing philosophical about it. It's just a rational organizational step. And I think we are moving in the right direction, although perhaps too slowly for my taste.

Mr. BOUCHER. Okay. Thank you for that comprehensive answer.

Dr. Straub, we would like to hear from you on this range of questions.

Dr. STRAUB. It's going to be very hard to give you better insight than my two previous colleagues.

The question you asked to begin with I would like to attack somewhat. That is, is there enough money in science? Are we funding science at the proper level? You've heard about the structural problems that we need to address, changing the priorities and so on, which is critically important, I think, and I certainly agree with both the previous speakers.

I think the call to crisis that Dr. Lederman brought before the country 6 months ago has been somewhat vilified. We don't need all that money. We can't get it. We shouldn't have it.

I must tell you that as a practicing scientist I am worried about the state of science in this country and about the state of funding. In the last 3 months I've had three postdoctoral scientists who should be starting in their scientific career tell me they are leaving science because they don't want to make the fight.

Now, you can say that you ought to let the market take its course and those good scientists will be funded and those that are not so much, so good won't be. I'm not so sure that those market forces make that selection.

Secondly, those forces are going down into the undergraduate level. Undergraduate students are seeing the problems with funding in science and they are saying, "No way. I'll do something else. I don't want to make that fight." They see their professors struggling. They understand what the graduate students are saying to each other.

Twenty years ago, it was Dr. Phil Handler who was then, I think, he was either President of the National Academy at that time or in Erich Bloch's role as Director of the National Science Foundation, pointed out the coupling between research funding and the production of scientists. And that the more you fund science, the more

hungry mouths you make; because when you fund me in the academic community, I fund graduate students and post docs.

Phil Handler said that we ought to break that connection so that we don't continuously do this, so we can have a rational growth. If you had market forces at play here, you get these tremendous exaggerations of too many, too few, too many, too few—too much funding and too little funding.

So I think one of the things we ought to address is, are there reasons to break this tight connection between scientific funding, especially at the universities, and the production of the scientists.

I personally believe there's going to be too few scientists, and I think we will find out in the year 2015 that we have too few as the pipeline problem is there. But one of the reasons the pipeline problem is there is people are going into the pipeline see no light at the end of the tunnel. They see no way to develop a career.

The final question you asked of us about what money should be applied to the emerging technologies, I think there is a plan that I've seen, a scheme that I've seen Mr. Bloch put forward on generic technologies that I'm very much interested in—I think is very good.

We have to develop below the level of emerging technology, capability that we can draw on, because the emerging technologies will draw on different generic technologies as it comes closer and closer to a market. And we have to develop a capability there that's above the academic laboratories, perhaps, somewhere at the Engineering Research Centers, that continuously has that capability. The Department of Defense has done a wonderful job of that.

And now the question is, can we spend that much money in the civilian community to make generic technologies work?

I think that's a good idea and I'd like to hear more about it.

Mr. BOUCHER. Thank you very much, Dr. Straub.

That concludes the Chair's questions.

Let me now recognize the Ranking Republican Member of the subcommittee, Mr. Packard.

Mr. PACKARD. We just had a call for a vote so, unfortunately, we will interrupt this panel, but I'll try to be brief and conclude mine before we have to go.

A concern that I think I've heard expressed this morning, and one that I've had for sometime is that as we have funded less and less from government sources for research and development because of deficits and other constraints, we have, at the same time, in my judgment, created disincentives for R&D in the private sector, through tax and economic policies.

And that seems to be, in my judgment, counterproductive. At the time that we begin to be forced backward in terms of—of public commitment to R&D, that is the very time we ought to create incentives for the private sector.

What would be your comments, your recommendations, in terms of reversing the trend that we've seen at least in the last few years, of moving away from public financing of R&D, because we can double R&D, applaud the doubling of our R&D budget of the public specter.

I support it, but at the same time, I recognize the realities of things. And even if we double it, that's still not going to keep pace

globally if we in some way don't unloose the real engine out there in the private sector in R&D.

What are your comments and recommendations to reverse this trend?

Dr. Bloch?

Mr. BLOCH. Let me start off by saying, the first thing Congress could have done a long time ago is make the R&D tax credit permanent. When there is a tax credit already in place, which I think is a very good thing. But having it on a temporary basis, renewing it every few years, doesn't instill confidence in industry to invest in their research, because they never know when that expires. That's one thing, and it doesn't take much to do that. I hope this is the year where that happens, but I'm not convinced yet.

The second thing that I think the R&D tax credit could address is what we talked about before—not just the spending that is going on by an individual—by—in an individual company, but also the spending that is going on in a cooperative kind of a way across industry sectors or within companies of an industry sector.

For instance, if there were a special credit for collaborative research, like SEMATECH, for instance, I think that would stimulate a lot of these activities coming together in a more cohesive kind of a way, and also have more critical resources to spend in it.

There is something in the R&D tax credit that makes special allowance for industry-funded academic research, the way I understand—and that is very good. I think there should be also a provision for making—for giving a special credit for collaborative kind of research, either between industries themselves, or between industry and the government, or between industry and academia—or all three.

I would say that would be my proposal. No sense inventing another credit, and you know, another thing like that, if you already have a framework there—it's a question of expanding that framework and trying to direct it into the areas where you might get the most benefit from it.

Mr. PACKARD. Dr. Likins?

Dr. LIKINS. I agree in every particular with what Erich has said, and can't add anything meaningful. You just have to remember that in industry, a research investment has to be just right economically. And these various incentives that you describe make a hell of a difference to the decision-making process in a company. They are very valuable. They have to be predictable. Government sometimes behaves in ways that companies can't count on. And there has to be enough of a planning horizon so they can justify investment.

Mr. PACKARD. Is there justification for considering changing also the protection of information and patent protection? Obviously, we've seen where—well, companies must recapture their invested—if they're going to succeed in doing R&D.

Is there a problem there that needs to be addressed by the policymakers and by the Congress?

Did you have a further comment on the other issues, too?

Dr. STRAUB. I couldn't agree more with my two previous colleagues. I think that—the other—another point of interfaces with smaller technologies. There is where there is—there is a lot of un-

certainty in small companies, small efforts involved, but mainly the big things.

This is an area which could be rewarded by a partnership with the Federal Government and the State government, and universities, and industries, all together. But there has to be a clearinghouse. Information flow amongst these small companies is much more difficult than among large companies. As our science authority in the State is a clearinghouse. So a small industry can come to a clearinghouse and say, who's doing what? Where can I get this? And that's very helpful. Encouraging that kind of help is not terribly expensive but I think important for, especially for the smaller industries, and I'd suggest that also as a point of investment.

Dr. LIKINS. In response to your question about intellectual property protection, it's a very complex area. And a proper response must vary from industry to industry, maybe even company to company. And in some industries intellectual property rights and the protections that go with patents and so on are not critical. Because things move so fast that it's not the duration of a patent that—that makes you whole; it's how quickly you get the next idea into the stream. And just staying ahead of the competition is the challenge.

So it's the organization that's got the—the improvements of the moment that is going to win the economic game, not the organization that has protected intellectual property.

I think in general, although, again, it's difficult to generalize, because various industries differ from each other radically. But in general, I believe that protecting intellectual property is less important in the '90s than it was in the '70s, because ideas move so fast today. And the critical comparative advantage in industrial competition today is the talents and capacities of the people.

Mr. PACKARD. I guess then the follow-up question of that, with that response—and I agree with you—would be what must be done then to enhance and to streamline the process of moving from a productive research into the development stage, what must we do, as government , working with the private sector, to hasten that process? Because it's the one that gets there fastest with the idea, in terms of a marketable product, and we're being beaten over and over again by—

Dr. LIKINS. I'd offer two suggestions. One, the various efforts to foster partnerships are a critical and successful strategy to that end. It creates a lot of movement of ideas across what had historically been barriers separating different kinds of people—researchers, and manufacturers, and so on. So the partnership strategy is a critical strategy.

It's also important that Americans become more skillful at learning about breakthroughs or new ideas elsewhere in the world. We complain a lot because people copy us, but we're just not very good at copying them—and they've got some damn good ideas, too.

Mr. PACKARD. One last question I have, Mr. Chairman, and that would be, we're constantly, and certainly recently, have debated here at the congressional level of big science versus little science, or other science, mainly with the space station and our efforts to recapture that project. But that certainly focused us on the whole question of where we ought to put our resources, government resources—limited as they may be.

We've got the SSC, the Superconducting Supercollider, we've got the high energy projects, and we've got the space station; a variety of big—big ticket items.

Are we—what is an appropriate balance? We don't want to eliminate those big projects because they do produce a great deal of very valuable and important science and basic research. But at the same time, are we doing some of those at the expense of other projects? And what is a good balance? And how—how should we, as policymakers, what are the tools we have available, or should we use to try to develop that balance that is workable?

Dr. Bloch? Mr. Bloch?

Mr. BLOCH. Mr. Packard, you're raising the right problem.

Mr. PACKARD. I knew you'd want to answer because I know the side of this question you've been on in the past.

Mr. BLOCH. Or, maybe you don't.

Mr. PACKARD. Maybe I don't. Please tell me.

[Laughter]

Dr. LIKINS. Maybe he'll change.

Mr. BLOCH. Maybe I'll change right in front of your eyes.

No, I don't.

But, look, I think that's a very important—important question. And it comes really down to the very basic notion of priority-setting. Priority-setting will cause a hold on the budget. And if one would do that rigorously, which we don't do, if we would do that very rigorously, and if one would have a scale in front, or in mind, namely, basic research and enhancing infrastructure, universities, some of the programs that Dr. Straub talked about—if you make that—that has to be the first priority. Because if you don't create people, if you don't have facilities, if you don't have—if you don't have institutions in place that are its leading edge, I don't know what you're going to do with the next big expenditure, an SSC or something like that.

The second thing is enhancing our economic competitiveness in programs that are clearly aimed at that because if you don't—if you are unable to pay for it, we are not going to have big programs.

And in my opinion, these large programs that you cited—SSC, space station—come last. They have to come last. If you can afford them, wonderful. If you can't afford them, we should drag them out and delay them somewhat.

Mr. PACKARD. I think Mr. Thornton and I must go or we're going to miss a vote. But we'll leave the chairman to coordinate the questions until we return.

Mr. THORNTON. Mr. Chairman, might I just—

Mr. BOUCHER. The gentleman from Arkansas.

Mr. THORNTON. Might I just express my appreciation to this panel. The suggestion by the panelists of the need for a careful evaluation of priorities, of the need to focus our intellectual capacity on meeting national needs, and the importance of doing so through consortia and relationships between all elements of our society do, indeed, call for a comprehensive approach to solving our problems.

At the end of World War II, for 2-1/2 years, we spent 2 percent of our GNP—$11-1/2 billion—in altruistic, charitable aid to Europe. It did nothing, except preserve Europe.

Then George Marshall and Harry Truman came up with the idea of a comprehensive plan to address the needs in Europe. An 8-month process of bipartisan research and cooperation was used to develop the dimensions of the plan.

During that 8-month period and before the first dollar was spent, results began to emerge. And over the next 3-1/2 years, a continuing expenditure of 2 percent of GNP reversed the course of the economies of Germany and Europe. And as a result—well, we know the lesson, they're eating our lunch today.

And my suggestion is that the times are as difficult today as they were then, and that it is time for us to have a comprehensive strategy as appropriate to our needs as those that we used to rebuild Europe after World War II.

I would appreciate any comments that any of you may make regarding this concept but I must go vote. I would appreciate reading about it in the record.

Mr. BOUCHER. Without objection, the record will remain open for the submission of written responses to that question on the part of any witness who chooses to do so.

I believe the gentleman from California, Mr. Packard, had propounded a question concerning priority-setting for big science versus small science projects, and Mr. Bloch had responded.

Mr. Likins—Dr. Likins, do you have a response?

Dr. LIKINS. I thought I might get away without having to respond to that question.

It's the right question and it's very gratifying that the question is being asked now in a way that it was not in prior years. And in some way you'd been driven by this—this budget agreement to make trade-offs that—that simply haven't always been made in this town.

My personal view is that we have had a tendency in the Federal Government to invest a higher percentage of our R&D money in defense than is appropriate, and a higher percentage of our R&D money in prestige projects than is appropriate; a lower percentage in the science and engineering infrastructure than is appropriate, and a lower percentage in industrial competitiveness kinds of projects than is appropriate.

So I would—if you want to work in those four categories, I would lean in the directions that I've just described. But it's very important to remember that the truth is in the details here. And you just can't sweep up all megaprojects and say they're all the same—they're very, very different.

The human genome project and the space station are as different as two large expenditures can be, in their character and the degree to which they can be subdivided, in the degree to which they're motivated. And obviously, the space station is not a science project. It's an engineering project that's an adventure. It's a human adventure of the kind that this Nation has committed itself to in times past. And it's a wonderfully exciting kind of a concept for us all to embrace, but it's not primarily a science project.

The supercollider is a science project. But it's one big experiment. The human genome is a large number of disaggregated experiments and explorations that have value when aggregated that exceeds the sum of the individual benefits of smaller projects. Very, very different kinds of ideas. And I think they have to be considered each on their own merits.

Mr. BOUCHER. Dr. Straub?

Dr. STRAUB. I do agree with the priority-setting that Erich Bloch has put forward but I would like to point out that one of the values of the big science projects is sometimes they drive very important technologies.

I think, for instance, the space program drove large scale integrated circuits and perhaps the Defense Department did too. The question is, will you have something else to drive those technologies that sometimes these large programs drive? And that has me concerned somewhat.

But I do agree that you can't have those projects unless you have the basic underlying infrastructure which Erich Bloch has referred to.

Mr. BOUCHER. Dr. Bloch, let me—well, I—very good. Let me recognize now the gentleman from New York, Mr. Boehlert, for a series of questions.

Mr. BOEHLERT. It's good to see you back, Mr. Bloch. I've enjoyed working with you over the years.

Let me ask, on page 11 of your testimony, when you talked—the previous page, you outlined something I think is very important, setting priorities.

But specifically, you say on page 11, "if we invest in prestige projects and neglect the basic infrastructure, or don't educate or attract the people who can design and utilize these projects, the benefits from these projects will be questionable."

Were you referring to the Superconducting Supercollider?

[Laughter]

Mr. BLOCH. I don't know what I was referring to, but—

Mr. BOEHLERT. Well, let me ask you specifically about—

Mr. BLOCH. —this is a very general statement, which certainly applies to the SSC, very clearly.

Mr. BOEHLERT. Would you agree with my analysis that it probably falls into the third of your three categories?

Mr. BLOCH. Absolutely.

Mr. BOEHLERT. If you were guiding me on my direction with respect to the SSC, and you know I've been on both sides of the issue. Initially I was a supporter because I believed that we could probably do what we said we were going to do within the budget and time constraints. But now I—that's completely evaporated; I don't believe it at all. I think it's a fairy tale.

We have to establish priorities. And you've pinpointed something very specific: we're partially at fault, the Congress—good gosh. We don't prioritize anything. I mean, and then we're having projects compete against each other.

Are you for veterans' benefits or are you for science?

Or do you want to take care of the needs of the homeless or are you for science?

And if we can get the college of cardinals to sit down at the beginning of the year with the Administration and map out a coherent strategy for funding research and development, I think we'd be better off.

But given the present system—and I can't change it all by myself, or none of us can, individually; collectively, we're going to try, and your guidance is much appreciated.

But as we try to establish priorities, I find it mindboggling to look in the budget and see a 120 percent increase for the SSC, for example, and in other areas we're going begging.

Are we—are we right to give such a high priority to a so-called prestige project like the SSC?

Mr. BLOCH. No, I—I don't think so. By the way, I think the SSC is an important kind of an instrument—there's no doubt about it. But if you can't afford it, in 1991 or in 1992 or in 1993, let it wait. That would be my approach. We have more important things to fund within the R&D budget: people, instrumentation, facilities, economic competitiveness-related projects. And to me those are more important. They are the basis on which one can afford later on to build something like the SSC.

Mr. BOEHLERT. Thank you.

Mr. BLOCH. A rich country can afford it. We are not as rich anymore as we were at one time.

The second thing I wanted to say is the following: especially on a project like that, which is highly visible, which serves a very small community, by the way; it doesn't serve a very big community.

It would be very important from the beginning, from the start, to make sure that there is international cooperation—that we are not the only one that is putting its money into it.

Mr. BOEHLERT. You say from the beginning?

Mr. BLOCH. From the beginning. It can't be done afterwards.

Mr. BOEHLERT. Do you know where we are right now?

Mr. BLOCH. Yes, I know where we are right now.

Mr. BOEHLERT. It's costing us for international participation.

Mr. BLOCH. Right.

Mr. BOEHLERT. We haven't received the first penny. We're actually paying.

Mr. BLOCH. But you see, you have to set the ground rules for that one from the start. You have to make the agreements from the beginning. You have to let the chips fall where they may. Maybe the SSC should not be built in the U.S. Maybe it should be built somewhere else.

These are discussions that one has to have before the fact. So I think international cooperation in both the scientific sense and a financial sense are very important for these big projects. We no longer can afford them ourselves.

And, secondly, they have to take a second—a secondary kind of a priority over things which are more important.

Mr. BOEHLERT. Dr. Likins, would you choose to avoid that question, or would you like to address it?

Dr. LIKINS. These are tough questions and I do believe that the answer you reach in response, let's say, to the SSC issue, depends on the thought process you take toward that answer.

If you simply focus on the superconducting supercollider, and ask, is it good science? Yes, it's a good science.

Is it science that would have an enormous impact potentially—

Mr. BOEHLERT. Maybe.

Dr. LIKINS. —on human knowledge? Maybe so.

It's very easy to walk down a path that—that causes you to say "yes, yes, yes, yes, yes" each stage of the way. And, of course, that's what you folks have done.

But if you ask the question differently, if you start off by saying: What if we had a fixed body of money that we were going to spend over a decade's time on scientific research in America; and what are the relative priorities, and what are the funds that you simply must commit to the education, and continuing education, of scientists, and to the greatly dispersed research enterprise of this country?

And if you were to stake out the—the needs in those areas, and then address these questions of industrial competitiveness, and the investments we must make in order to maintain the strength of our economy, and get those priorities fixed in your mind, then you're beginning to narrow the availability of funds.

When you approach the question that way, then I think I personally—speaking only for myself—am drawn to the conclusion that we're making a disproportionate allocation of funds toward the supercollider.

Mr. BOEHLERT. And you're outlining exactly the way I think we should be proceeding. And, Mr. Bloch, you have, too, and I think the chairman agrees with that.

It's so frustrating to address overall R&D and look at the big pot, how much we want to commit, and then start prioritizing, when we get into this haphazard way of doing things.

For example, the National Science Foundation—I don't have to remind Mr. Bloch, that this committee has been very good to the National Science Foundation, for good and sufficient reason. You have no trouble with the authorizers, it's those appropriators we have to get you to lecture before.

But I have to be encouraged—and I hope you share this view, but I don't want to set you up, I'll ask you for it.

I'm encouraged by the fact that we have in the White House—Dr. Bromley is the Science Adviser to the President. In my memory, he is the first—well, all the Science Advisers had very good credentials, but he is the first person that I have seen that lives up to the role as I envision—someone who has the ear of the President, which is encouraging; probably the first Science Adviser in recent memory who has. And I see the Administration moving in the right direction. We share some disappointments but overall, I'm upbeat about the future.

But I just get back to this frustration on priorities. Do we want to go ahead with a space station and human genome and the Superconducting Supercollider, and a national aerospace plane, and this and that.

And then I say to myself, what are we doing for basic science education? And how about the Engineering Research Centers that are so important?

Incidentally, let me ask you that specific question, Mr. Bloch, you were so instrumental in getting the ERCs going—what's your evaluation so far, and should we be putting more money into more Engineering Research Centers?

Mr. BLOCH. Definitely, we should put more money into the centers, in the following sense: that we should have more centers than 19, or whatever the number is, that exist today.

I'm not so sure that each center needs much more money than it has today. Let them fight among—let them compete among the existing funds and also attract funding from industry and from the universities themselves, and from the States, and what have you.

But I sure would be in favor of increasing the number of centers.

When you were out, I mentioned I think what the centers have accomplished is a great deal. And the market test speaks for itself—the participation by industry has been very high. The investment by industry has been very high.

Dr. Likins pointed out the fallout in terms of the education, undergraduate education, as well as graduate education; knowledge generation and so forth. And that's really what the centers were supposed to do.

I think they also really focused the attention of academic institution on—on multidisciplinary research instead of strictly the disciplinary kind of research, which is important—no doubt about it—but it's not the total story.

And making that kind of a cultural change almost in universities, I think both the engineering research centers and the science and technology centers have brought that about, or have at least contributed to it. So I—I would give them an A-plus.

Mr. BOEHLERT. Nine years ago when I first came here and was assigned to this committee, I mean, engineers and the physical science were almost an afterthought. And now we're moving in the right direction. And the good news is that the government, collectively, all of us, are doing some things and doing them very well.

The Engineer Research Centers are one. I couldn't be any happier and I would assume you share this view on our supercomputer initiative.

Mr. BLOCH. Yes.

Mr. BOEHLERT. We're moving in the right direction.

And I wish I could stay longer but, Mr. Chairman, the Commissioner of Social Security is waiting for me in my office. Not to sign me up. I'm not eligible for that. But I've got to deal with her on some problems.

Dr. LIKINS. May I, even in your absence, if that is necessary, make a comment?

Erich has a uniquely informed perspective about the Centers as a whole, and I know a great deal about one Center. There is an Engineering Research Center at Lehigh University for the advanced technology of large structural systems. Its intended impact is on the construction industry. But it is a very tough industry to penetrate for a bunch of academics because that is an industry that doesn't do much research historically in America.

The competition in Japan and in Korea are much more committed to R&D in the construction industry. And we have had an uphill battle. It has been a glorious success. We've gotten compa-

nies involved in our enterprise that at the beginning just couldn't be bothered with a bunch of professors trying to improve the construction industry. We, I think, have succeeded in the eyes of the NSF, but that is not the point. The point is we've succeeded in the eyes of the companies in the construction industry who are heeding our message now in a way that they did not when we began whenever that was, 5, 6, 7 years ago.

Mr. BOEHLERT. That's that partnership that is so essential, the university community, the private sector, and the government.

As I take leave, just let me emphasize once more that we owe collectively a debt of gratitude to Mr. Bloch. Because I, once again, when I first came here the NSF used to be the butt of weekly jokes from Proxmire over in the Senate—the Golden Fleece Awards. Of course, more often than not he didn't know what he was talking about. I think we can concede that. But the NSF right now is one of the premiere agencies in endeavors involving the Federal Government, and that is a personal tribute to the commitment and dedication of our witness today, Mr. Bloch. And it is good to see you.

Mr. BLOCH. Thank you.

Mr. BOEHLERT. Thank you.

Mr. BOUCHER. The Chair thanks the gentleman from New York for his contributions this morning.

Let me focus this panel finally on one other issue, and that is, the basic health of the university/private sector partnership for basic research, and particularly with reference to the role of the private sector in that partnership. There have been some suggestions that while companies may commit money to university-based research that oftentimes they're not committing their best personnel, and I wonder if that's an experience that is widespread. And, if you would comment on whether or not that is something about which we should be concerned?

Dr. Likins, would you like to begin?

Dr. LIKINS. You need to think carefully about the premise that companies are committing money to universities for basic research, let alone contributing people. Because remember, they've got to get the return on that investment. That's the nature of their enterprise. And, if the research is sufficiently fundamental, as I understood your term basic to imply, then it's almost impossible to recapture the benefits.

We find that the companies that do contribute to our research, and Lehigh probably has a higher proportion of private funding than the vast majority of American universities, we find those companies are really interested in our people, not in the research project. IBM has a longstanding relationship with Lehigh faculty and they fund their work for years and years and years. But you get these folks from industry in a serious conversation and they'll tell you that what they want is the relationship with the institution because of the young people, or the old people, who receive degrees and progress from that institution into industry, and hopefully into IBM.

Similarly, the faculty play consulting roles that are critical.

So there isn't an awful lot of money that flows into basic research in universities. Nor should there be. Nor will there ever be.

If the research is sufficiently fundamental, then it has to come from sources that can benefit from a diffused return on that investment.

Mr. BOUCHER. Dr. Bloch?

Mr. BLOCH. Yes, let me answer your question also. Let me say at the outset, I think there has been a change, however, over the last, I would say decade, or maybe a little bit less of a decade, between the industry and academia in terms of their relationship. I think it's a lot closer today. I think it's more widespread than it was. In the past, it was a few companies. Today, it's many more companies, and the example of Dr. Likins on his Engineering Research Centers of an industry sector that was not involved at all in basic research is a good example. So we should acknowledge that.

We have a long ways to go, by the way, in that relationship. But for whatever reason, industry does the funding, and sometimes it's for knowledge and sometimes it's access to people, and so forth. I think that that is a healthy kind of a relationship because the flow of information back and forth has to be done between people. It can't be legislated. It can't be a piece of paper, and so forth. So I think whatever we can do to motivate this, and a tax credit is one way of motivating it—to go back to a previous question—I think we should continue.

By the way, let me say at the same time, if the same relationship would exist between government laboratories and industry that exist today between academia and industry, I think we would all be better off. There is an underutilized resource which industry is not partaking of, and the fault lies on both sides.

Mr. BOUCHER. Okay. Well, I would like to thank this panel for its appearance this morning and for the comments and suggestions. We will find those very helpful as this inquiry continues.

Mr. BOUCHER. Now, I would like to introduce the second panel for the day, and that will be a panel of four witnesses. And we welcome to the subcommittee this morning Dr. Norman Gjostein, the Director of Materials Research for the Ford Motor Company in Dearborn, Michigan; Dr. James Solberg, Director of Engineering Research for Intelligent Manufacturing at Purdue University; Dr. Steven Weinstein, Division Manager of Bellcore, from Morristown, New Jersey; Dr. Anthony Acampora, the Director for the Center of Telecommunications Research at Columbia University.

Gentlemen, we welcome each of you. Without objection, your prepared statement will be made a part of the record, and we would be pleased to receive your oral summaries.

And, Dr. Gjostein, we'll begin with you.

STATEMENTS OF NORMAN A. GJOSTEIN, PH.D., DIRECTOR, MATERIALS RESEARCH LABORATORY, FORD MOTOR COMPANY, DEARBORN, MICHIGAN; JAMES J. SOLBERG, PH.D., DIRECTOR, ENGINEERING RESEARCH CENTER FOR INTELLIGENT MANUFACTURING, PURDUE UNIVERSITY, WEST LAFAYETTE, INDIANA; STEVEN WEINSTEIN, PH.D., DIVISION MANAGER, BELLCORE, MORRISTOWN, NEW JERSEY; ANTHONY ACAMPORA, PH.D., DIRECTOR, CENTER FOR TELECOMMUNICATIONS RESEARCH, COLUMBIA UNIVERSITY, NEW YORK, NEW YORK

Dr. GJOSTEIN. Thank you very much, Mr. Chairman and members of the committee. Ford appreciates the opportunity to present its views on the role of basic research in economic competitiveness.

I speak today from the perspective of a private sector research and development manager who has spent over 30 years conducting research and managing various research functions at Ford Motor Company. Currently, I am Director of the Materials Research Laboratory at Ford.

I also serve as chairman of an internal committee that manages Ford's University Research Program. And, in addition, I have participated recently in the two studies done by the Council on Competitiveness.

Let me begin by saying that at Ford Motor Company we believe that the implementation of new technology in our products, our manufacturing processes and our engineering design methodologies is vital to our future competitiveness. However, the rate at which we successfully introduce new technology is not limited at present by the number of new concepts that flow from basic research. Rather, I believe it's determined by how well we manage our own internal R&D processes and our ability to manage the risk associated with bringing new technology into the marketplace. We have improved our technology management processes, and we have good reason to believe that we will greatly improve our capability to introduce new technologies in the future.

But because university research is important to us, we believe that government, university and industrial sectors must work cooperatively to enhance the probability that such fundamental research will ultimately be used by industry.

In fostering this partnership Ford believes that there are some key government roles. First, provide adequate funding for basic research at universities, and we think funding of the new engineering research programs should not come at the expense of basic research. There should be more programs in which the government matches industry funding of university research at a ratio greater than 1 to 1. Another is providing joint funding with industry for applied research and development work. Because industry is close to the marketplace, it should set the research agenda in such joint programs. Funding should be targeted at high-risk, high-payoff concepts, particularly where cooperation of different industries is required. An excellent example of this is the DOE-sponsored Electric Vehicle Program involving Ford and GE, which resulted in the development of a very efficient electric trans-axle and has led to Ford's current preproduction electric vehicle build program.

Next, sponsor research oriented towards the needs of high production volume industries or, as you've been talking today, civilian industries. The current emphasis is on research oriented towards military and aerospace industries. The thinking seems to be that such high-tech research will have dual usage and eventually trickle down to the civilian industries. This is often not the case for the auto industry, for example, because of our requirements for cost effective technology that can be implemented with very high reliability and at very large production volumes.

Next, target government research to meet industry needs. The auto industry has found it difficult to absorb technology from the National Laboratories. We urge the National Laboratory management to follow the National—[2] or the NIST model; that is, they should go out and get to know better the needs of their customers in industry. This is what we practice inside our own operations. Research people in Ford, for example, have to get to know the needs of their customers in the operation. We are pleased to see, by the way, that the Oak Ridge National Laboratory is following this pattern. They have been to see us on several occasions.

Next, participate directly in private sector research projects. There's a growing number of opportunities for the government to participate in industry precompetitive consortia. The Big 3 have recently formed an Automotive Composites Consortium which as yet has no government participation. On the other hand, the DOE and EPRI are involved with the Big 3 in a Battery Development Consortium which will also involve the National Laboratories and the universities.

At this point I'd like to make a few statements about Ford's University Research Program. The program is described in more detail in Attachment I, but I'd like to highlight a few aspects here.

Currently, Ford supports over 80 university research programs at 29 universities, including all of the top 20 U.S. engineering schools. We support key work also at key universities in Europe and the UK because of the global character of our R&D infrastructure. The research work covers seven major areas: computer-aided engineering; another area is engines, emissions, and fuels; electronic devices and systems; structural and electronic materials; manufacturing, automotive engineering topics; and physical and chemical sciences.

We are not supporting this work for altruistic motives. We choose research areas that are relevant to our long-term needs. Every program has a Ford sponsor who is responsible for ensuring that the research work flows into the company. Most of our grants, probably over 90 percent, are awarded directly to faculty members who we know are conducting research that is relevant to our interests. The research work is usually conducted by graduate students or postdocs under the direction of the faculty member. Most projects are supported for 3—a minimum of 3 to 4 years to ensure that Ph.D. candidates will be able to complete their thesis projects. We have found this system is the most effective way for Ford to benefit from university research.

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[2]National Institute of Standards and Technology (NIST).

To a lesser, but significant level, Ford's university research program also supports multi-industry consortia at selected universities. Included in this category is the support for NSF Engineering Research Centers at Carnegie Mellon University for design, Purdue University for manufacturing, University of Wisconsin for plasma processing, and Ohio State University for net shape forming.

The initial concern we had with centers supported by several industries was the potential difficulty of finding projects that would be relevant to both the interests of Ford as well as the other participating industrial partners. In the case of the Carnegie Mellon Design Center, we have been able to overcome this concern, and over a 4-year period we have conducted a successful joint research program with the Center involving new software for computer-aided design and processes for rapid prototyping. In the longer term, we believe that these tools have the potential to reduce our product lead time, making us more efficient and more responsive to the quickly changing marketplace.

Our relationship with the Center for Intelligent Manufacturing at Purdue is in a much earlier stage of development, in that we are working together to find an appropriate area of joint research. We have every reason to believe, however, that this will be accomplished shortly and this effort will follow the same successful path as the CMU Design Center.

In closing, let me say that Ford Motor Company is actively involved in supporting long range research in universities. In general, we believe we have benefited from a steady flow of new knowledge from these programs, and I have listed some of them in Attachment I. It is a short list actually. In particular, we applaud NSF's initiation of the Engineering Research Center program, and our successful interactions with several ERCs will cause us to explore more in the future.

Thank you very much.

[The prepared statement of Dr. Gjostein follows:]

Statement of Dr. Norman A. Gjostein
Director of the Materials Research Laboratory
Research Staff, Ford Motor Company
Before the Subcommittee on Science
Committee on Science, Space and Technology
United States House of Representatives
on the Role of Basic Research in Economic Competitiveness
June 20, 1991

Mr. Chairman and Members of the Committee:

Ford appreciates the opportunity to present its views on the role of basic research in economic competitiveness.

I speak today from the perspective of a private sector research and development manager who has spent over thirty years conducting research and managing various research functions at Ford Motor Company. Currently, I am Director of the Materials Research Laboratory at Ford Motor Company.

I also serve as chairman of an internal committee that manages Ford Motor Company's University Research Program. In addition, I have participated in two recent studies of the Council on Competitive-

ness on "Picking up the Pace: The Commercial Challenge to American Innovation" and "Gaining New Ground: Technology Priorities for America's Future."

Let me begin by saying that at Ford Motor Company we believe that the implementation of new technology in our products, manufacturing processes and engineering design methodologies is vital to our future competitiveness. However, the rate at which we successfully introduce new technology is not limited at present by the number of new concepts that flow from basic research. Rather, it is determined by how well we manage our internal R&D processes and our ability to manage the risk associated with bringing new technology to the marketplace. We have improved our technology management processes, and we have good reason to believe that we will greatly improve our capability to introduce new technologies in the future.

Because university research is important to us, we believe that government, university and industrial sectors must work cooperatively to enhance the probability that such fundamental research will ultimately be used by industry.

In fostering this partnership Ford believes some key government roles are:

- Provide adequate funding of basic research at universities. Funding of new engineering research programs should not come at the expense of basic research.

- There should be more programs in which the government matches industry funding of university research at a ratio greater than 1:1.

- Provide joint funding with industry for applied research and development work. Because industry is close to the marketplace, it should set the research agenda in such joint programs. Funding should be targeted for high risk - high payoff concepts, particularly where cooperation of different industries is required. An excellent example is the DOE-sponsored Electric Vehicle Program, involving Ford and GE, which resulted in the

development of a very efficient electric transaxle and has led to Ford's current pre-production electric vehicle build program.

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- Target government research to meet industry needs. The auto industry has found it difficult to absorb technology from the National Laboratories. We urge National Laboratory management to follow the National Institute for Science and Technology (NIST) model -- they should get to know the needs of their

"customers" in industry. We are pleased to see the Oakridge National Laboratory following this pattern.

- Participate directly in private-sector research projects. There are a growing number of opportunities for the government to participate in industry precompetitive consortia. The Big 3 have formed an Automotive Composites Consortium which as yet has no government participation, but the DOE and EPRI are involved with the Big 3 in a Battery Development Consortium which will also involve the National Laboratories and universities.

At this point I would like to make a few statements about Ford's University Research Program. The program is described in more detail in Attachment I, but I would like to highlight a few aspects of the program in this oral statement.

Currently, Ford supports over 80 university research programs at 29 U.S. universities including all of the top 20 U.S. engineering

schools. We also support work at key universities in Europe and the UK because of the global character of the R&D infrastructure relevant to our interests. The research work covers seven major areas: computer-aided engineering, engines/emissions/fuels, electronic devices and systems, structural and electronic materials, manufacturing, automotive engineering, and physical/chemical sciences.

We are not supporting this work for altruistic motives. We choose research areas that are relevant to our long-term needs. Every program has a Ford sponsor(s) who is responsible for ensuring that the research work flows into the company. Most of our grants (90%) are awarded directly to faculty members who we know are conducting research that is relevant to our interests. The research work is usually conducted by graduate students or post-doctoral students under the direction of the faculty member. Most projects are supported for a minimum of 3-4 years to ensure that PhD candidates will be able to complete their thesis projects. We have found that this system is the most effective way for Ford to benefit from university research.

To a lesser, but significant, level Ford's university research program also supports multi-industry consortia at selected universities. Included in this category is support for National Science Foundation (NSF) Engineering Research Centers at Carnegie Mellon University (Design), Purdue University (Manufacturing), University of Wisconsin (Plasma Processing) and Ohio State University (Net Shape Forming). The initial concern we had with centers supported by several industries was the potential difficulty of finding projects that would be relevant to the interests of Ford and the other participating industrial partners. In the case of the Carnegie Mellon Design Center, we have been able to overcome this concern, and over a four-year period we have conducted a successful joint research program with the Center involving new software for computer-aided design (NOODLES) and processes for rapid prototyping. In the longer term, we believe these tools have the potential to reduce our product lead time, making us more efficient and more responsive to a quickly changing marketplace.

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we are working together to find an appropriate area of joint research. We have every reason to believe, however, that this will be accomplished shortly and that this effort will follow the same successful path as the CMU Design Center.

In closing, let me say that Ford Motor Company is actively involved in supporting long-range research in universities. In general we believe we have benefitted from a steady flow of new knowledge from these programs (Attachment I). In particular, we applaud NSF's initiation of the Engineering Research Center (ERC) program. Our successful interactions with several ERCs will cause us to explore relationships with other ERCs in the future.

FORD MOTOR COMPANY
UNIVERSITY RESEARCH PROGRAM

Ford Motor Company is attempting to leverage its internal research and development capabilities through the support of university research.

The major objectives of the program are:

- To support the generation of new scientific and engineering knowledge by universities that are doing research in fields relevant to the technical needs of Ford Motor Company.
- To influence universities to conduct research in areas of interest to Ford Motor Company.
- To discern and capitalize on emerging technologies that could have a major impact on Ford Motor Company.
- To transfer university research results and technical concepts to Ford Motor Company technical activities.
- To gain access to top undergraduate and graduate students.

Each year an internal committee judges and prioritizes university research proposals based on the quality of the research and the potential relevance of the research to Ford's long-term needs. The committee has broad representation including Ford of Europe personnel. Typically over 100 proposals are received annually and about 15-20% are funded. Programs are usually planned for 3-4 years in order to support graduate student theses and to ensure that adequate time is available to achieve significant accomplishments. Each program must have an internal sponsor or nominator who strongly supports the work and ensures that the research results are ultimately transferred to the Company.

Over 80 programs are currently being supported at 29 U.S. universities, including the top 20 U.S. engineering schools. Nine universities in Europe and U.K. are also included.

The research work covers seven major areas: CAE, engines/emissions and fuels, electronic devices and systems, structural and electronic materials, manufacturing, automotive engineering, and physical/chemical sciences. The internal committee manages the portfolio of programs, ensures that the program content is appropriate and that there is a proper balance of priorities. Periodically the committee conducts an evaluation of the program to determine how well the program is meeting the objectives stated above.

The managed portfolio has been in existence for nearly four years and to date the program has been judged a success both by the academic community and by Ford Motor Company. Ford R/D programs have benefitted from a steady flow of new knowledge from universities, such as: a new solid modeler (NOODLES) for computer-aided design and a rapid prototyping process from Carnegie Mellon University Design Center (ERC); an engine knock model from MIT which was incorporated in Ford's engine simulation model; a design tool from University of Wisconsin for sizing buffers in manufacturing lines which reduces computation time by 20x; computational techniques from University of Michigan which have reduced sheet metal forming modeling computation time by 2x; software for automated design of engine components from University of Michigan; diesel combustion models from University of London; diamond thin film technology from Pennsylvania State University; active noise control technology from Pennsylvania State University and a wealth of knowledge on advanced materials from several universities. This is an excerpt from a list of key benefits that is too long to repeat here.

Apart from the technical accomplishments we should not overlook the numerous people-to-people interactions that have taken place between Ford's technical personnel and university faculty and students. In most cases the joint efforts have led to genuine teamwork and a better understanding between the two cultures. We believe universities have a greater understanding of the technical needs of our industry that will make us more competitive. Ford's R/D community has benefitted also from hiring a significant number of highly talented PhD and MS level students in a wide spectrum of disciplines. On the other hand, Ford's funding over the four years that this program has existed has supported 75 graduate students and resulted in the publication of over 200 papers by faculty and students.

Mr. BOUCHER. Excuse me. Dr. Solberg, we'll be happy to hear from you, sir.

Dr. SOLBERG. Mr. Chairman, it's a pleasure to appear before you to discuss the role of university-based research in support of industrial competitiveness. I'm Director of one of these ERCs, and from that perspective I will focus my remarks today on the positive lessons learned from the rather unique experiment in the ERCs over the past few years.

As you know, the National Science Foundation established the ERC program in 1985 with the specific mission of helping American industry become more competitive by addressing a number of perceived weaknesses in the infrastructure that supports innovation. These weaknesses included such factors as the narrowness of technical disciplines and the way we teach them, the gap between universities and industry, and the lack of attention to systems issues.

Part of the mission of the ERCs was educational, to bring into the university a much better sense of industrial needs, so that the education provided to students will prepare them better for the competitive environment they will face. This part of the mission is, perhaps, the clearest and most obvious benefit over the long term. However, we are also attempting to marshal the considerable intellectual resources of the universities to serving industrial needs directly by focusing our research efforts in that direction.

The ERCs represent a new and different approach to economically significant research in several ways. First, they are set up specifically to deal with issues critical to industrial competitiveness. The research is driven by identified industrial needs, instead of the pure intellectual curiosity or the good science that traditionally generates academic research. Furthermore, it is strategically planned over a long term, rather than walking randomly from opportunity to opportunity. Companies participate directly in the work along with faculty and students from the universities. One of the specific objectives of the ERC is to create a new climate on the campuses that encourages cross-disciplinary teamwork and the so-called systems approach to complex problems. This approach contrasts with the more common view of research as an individual scholar pursuing the frontiers of knowledge in some highly specialized area. Although both kinds of research are needed, most problems of modern manufacturing are so complex that they demand the integrated team approach.

A profound change, which some have called a change of culture—

Mr. BOUCHER. Dr. Solberg, I hate to interrupt you, but I am going to have to go to the floor. This is unexpected and I apologize for it. I'll come back as quickly as I can.

So there being no one else to chair the hearing, it will be recessed temporarily.

[Recess.]

Mr. THORNTON [ASSUMING THE CHAIR]. The hearing will come to order.

We are having a more significant set of voting exercises in the House of Representatives chamber than is normal. We often have

to interrupt hearings for that purpose, but this has really been an unusual morning in that regard.

I want to thank each of our witnesses for their patience to accommodate our schedule, and Dr. Solberg, will you please continue with your testimony.

Dr. SOLBERG. Yes, I'll resume about where I left off. I was attempting to recount some of the positive lessons learned from our particular ERC.

A profound change, which some have called a change of culture, has occurred at those universities where ERCs are located. It would be better to call it an enrichment of the culture because we are really adding to the strengths of our traditional approaches to graduate research and education which are still, as you know, the envy of the world.

Regardless of how the transformation is labeled, the ERCs have cultivated an evolution to a new academic research environment in which the disciplines work together to tackle the larger scale and more technically diverse problems that occur in advanced technology today. The faculty are also working much more closely with partners in industry, which provides direct and indirect benefits to both sides. The smooth transition of research results from the university laboratories into industrial use, the awareness of the real needs of industry on the part of researchers, and the educational process itself are all better served by this new environment.

To cite just a few examples of the kind of research that the ERC enabled, a team of faculty and students, working together with practicing engineers from several of our partner companies, created a novel system for designing and machining metal parts. This system, which they called a Quick Turnaround Cell, enables a manufacturer to produce one-of-a-kind parts in a matter of a few minutes, as opposed to the several weeks that would normally be required. The system is now installed for use at the Army Missile Command in Huntsville, AL and is under consideration by several private companies for commercial development.

Other examples I could cite from my own center involve a software system to aid designers of cast iron flywheels, now in use in Cummins Engine Company, improvements in spray painting technology now employed throughout the industry by Ransburg Corporation and other suppliers of spray paint equipment, and a new approach to noncontact temperature measurement which has resulted in new instruments and applications in several metal processing industries. I have numerous such examples, as do other ERCs.

These examples support several important conclusions. First, it is definitely possible—although I would not say easy—to find problems that are simultaneously suitable for academic research and important to industry. There was good fundamental science aspects involved in each of these projects and there were intensely interested customers awaiting the results of the research. The collaboration between the university researchers and the company engineers was established as the project was being defined, continued throughout the project, and carried over into final implementation. Both the companies and the university benefited from the collaboration. Finally, none of this would have happened without the ERC or some similar kind of organization.

The quality and performance of individual ERCs and the program as a whole have been held up to close scrutiny. The original selection process, involving a series of panels and peer reviews, was extremely competitive. Subsequently, studies by the National Academy of Engineering, the Government Accounting Office, numerous internal reviews, site visits by distinguished representatives of industry, government and academia, have all evaluated the ERCs thoroughly. The general conclusion from all of these reviews is that the experiment has been a success beyond anyone's expectation.

From a purely cost-effectiveness standpoint, the ERC has achieved a large effect with a relatively small amount of money. The program was successful despite the fact that it was never funded up to original expectations. The pooling of public and industrial funds, together with the pooling of ideas and effort that accompanies the funding, produces a highly leveraged result. I believe that the mix of Federal funding and industry funding is healthy and appropriate.

The coverage of the existing centers, from either a technical view or the number of companies and universities influenced, is still quite small. In order to have a large impact upon the Nation's industrial practices and the educational pipeline, there should be more such centers. Even though our center could do more with funding—I would like to receive it—I would have to say, from your point of view, what we need first is more centers. The evidence that they work is substantial, and the models for how to do it are available.

Thank you.

[The prepared statement of Dr. Solberg follows:]

June 20, 1991

Statement of James J. Solberg
Director, Engineering Research Center
for Intelligent Manufacturing Systems
Purdue University
West Lafayette, IN

Mr. Chairman and members of the committee:

It is a pleasure to appear before you to discuss the role of university-based research in support of industrial competitiveness. I will not recount the history of our loss of technical dominance, nor belabor the well known gap between invention and implementation that we have suffered in this country. Instead, I will focus my remarks on the positive lessons learned from the rather unique experiment in Engineering Research Centers over the past few years.

The National Science Foundation established the ERC program in 1985. It was designed specifically to help American industry become more competitive by addressing a number of perceived weaknesses in the infrastructure that supports innovation. These weaknesses included such factors as the narrowness of technical disciplines, the gap between universities and industry, and the lack of attention to "systems" issues.

Part of the mission of the ERCs is to bring into the university a much better sense of industrial needs, so that the education provided to students will prepare them better for the competitive environment they will face. This part of the mission provides, perhaps, the clearest and most obvious benefit over the long term. However, we are also attempting to marshal the considerable intellectual resources of the universities to serving industrial needs by focusing our research efforts in this direction.

The ERCs represent a new and different approach to economically significant research in several ways. First, they are set up specifically to deal with issues critical to industrial competitiveness. The research is driven by identified industrial needs, instead of the pure intellectual curiosity or the "good science" that traditionally generates academic research. Companies participate directly in the work, along with faculty and students from the universities. One of the specific objectives of the

ERCs is to create a new climate on the campuses that encourages cross-disciplinary teamwork and the so-called "systems approach" to complex problems. This approach contrasts with the more common view of research as an individual scholar pursuing the frontiers of knowledge in some highly specialized area. Although both kinds of research are needed, most problems of modern manufacturing are so complex that they demand the integrated team approach.

A profound change, which some have called a "change of culture," has occurred at those universities where ERCs are located. It would be better to call it an enrichment of the culture, because we are really adding to the strengths of our traditional approaches to graduate research and education, which are still the envy of the world. Regardless of how the transformation is labeled, the ERCs have cultivated an evolution to a new academic research environment in which the disciplines work together to tackle the larger scale and more technically diverse problems that occur in advanced technology today. The faculty are also working much more closely with partners in industry, which provides direct and indirect benefits to both sides. The smooth transition of research results from the university laboratories into industrial use, the awareness of the real needs of industry on the part of the researchers, and the educational process itself are all better served by this new environment.

To cite just a few examples of the kind of research that the ERC enabled, a team of faculty and students, working together with practicing engineers from several of our partner companies, created a novel system for designing and machining metal parts. This system, which they called a Quick Turnaround Cell, enables a manufacturer to produce one-of-a-kind parts in a matter of a few minutes, as opposed to the several weeks that would normally be required. The system is now installed for use at the Army Missile Command in Huntsville, Alabama, and is under consideration by several private companies for commercial development.

Other examples I could cite from my own Center involve a software system to aid designers of cast iron flywheels, now in use in Cummins Engine Company, improvements in spray painting technology now employed throughout the industry by Ransburg Corporation and other suppliers of spray paint equipment, and a new approach to non-contact temperature measurement which has resulted in new instruments and

applications in several metal processing industries. I have numerous such examples, as do other ERCs.

These examples support several important conclusions. First, it is definitely possible (though I would not say easy) to find problems that are simultaneously suitable for academic research and important to industry. There was good fundamental science involved in each of these projects and there were intensely interested "customers" awaiting the results of the research. The collaboration between the university researchers and the company engineers was established as the project was being defined, continued throughout the project, and carried over into final implementation. Both the companies and the university benefited from the collaboration. Finally, none of this would have happened without the ERC, or some similar kind of organization.

The quality and performance of individual ERCs and the program as a whole have been held up to close scrutiny. The original selection process, involving a series of panels and peer reviews, was extremely competitive. Subsequently, studies by the National Academy of Engineering, the Government Accounting Office, numerous internal reviews, site visits by distinguished representatives of industry, government and academia, have all evaluated the ERCs thoroughly. The general conclusion from all of these reviews is that the experiment has been a great success.

From a purely cost-effectiveness standpoint, the ERC has achieved a large effect with a relatively small amount of money. The program was successful despite the fact that it was never funded up to original expectations. The pooling of public and industrial funds, together with the pooling of ideas and effort that accompanies the funding, produces a highly leveraged result. I believe that the mix of federal funding and industry funding is healthy and appropriate.

The coverage of the existing centers, from either a technical view or the number of companies and universities influenced, is still quite small. In order to have a large impact upon the nation's industrial practices and the educational pipeline, there should be more such centers. The evidence that they work is substantial, and the models for how to do it are available.

4

Biographical Sketch

James J. Solberg is the Director of the Engineering Research Center for Intelligent Manufacturing Systems and a Professor of Industrial Engineering at Purdue University in West Lafayette, Indiana. He received a B.A. degree from Harvard in mathematics in 1964, a M.A. in mathematics and a M.S. in industrial engineering from the University of Michigan in 1967, and a Ph.D. in industrial engineering from the University of Michigan in 1969.

In addition to several teaching awards, Dr. Solberg won the "Book of the Year" Award in 1977 and the David F. Baker Distinguished Research Award from the Institute of Industrial Engineers in 1982. He is member of the National Academy of Engineering.

As Director of the Engineering Research Center for Intelligent Manufacturing Systems since its formation in 1985, Dr. Solberg has managed a cross-disciplinary program in research, education, and technology transfer involving some forty professors and 150 students.

Mr. THORNTON. Thank you, Dr. Solberg.

Dr. Weinstein.

Dr. WEINSTEIN. Good morning, Mr. Chairman, and members of the committee. Maybe I should move the microphone over.

Mr. THORNTON. Please do.

Dr. WEINSTEIN. I appreciate the invitation to testify, and I'll try to summarize it in a few minutes. I would like first to define my company and its research directions.

Bellcore is a research, software development, and systems engineering organization with 8,000 employees that is jointly owned by all of the Bell Operating Companies. It is itself an industrial consortium. Bellcore's mission is to support exchange and exchange access communication services offered by those companies and coordinate telecommunications national defense preparedness. I manage applied research on the subject of future public network communication services needed to support emerging communication applications. I'm particularly concerned with the interfaces between customer and public network equipment.

Bellcore, in general, generates technical insights and technologies for creating a public network that will give users access in voice, data, and video media to each other and to a wide range of information providers, and which will support applications such as distributed classrooms, medical image exchange and consulting, multimedia information delivery, and personalized multimedia communication.

Bellcore highly values its interactions and collaborations with university researchers and their programs, and one of my responsibilities is to represent Bellcore in Columbia University's Center for Telecommunications Research, CTR, which will be described to you in more detail by Professor Acampora.

My Bellcore colleagues and I are closely involved with CTR's ACORN project in high-speed lightwave networking, which we consider an outstanding example of industrial and academic collaboration.

The points I would like to make today are, first, industrial research and academic research provide different economic benefits. Both seek to generate a potential for economic impact commensurate with the costs. Unlike the more proprietary economic benefits of industrial research, which can for a while provide a competitive market advantage, the benefits of university research are most likely to flow directly to a wide range of companies and industries and/or members of a research community, and thereafter to society as a whole. The most important products of university research, as most of the previous speakers have suggested, are scientific knowledge and a development of students into creative scientists and engineers oriented to industry needs. The combined results of these two different kinds of research efforts underlie economic growth and industrial competitiveness.

Second, the forms for academic/industrial collaboration are still evolving. Engineering centers are a very promising and very successful initiative, but other forms should also be supported.

Third, Congress should consider long-term support for engineering centers, for information networking which links academic and industrial researchers, for access from high schools and public li-

braries to academic and industrial information resources, for exchange and internship programs between universities and industrial R&D organizations, and for academic/industrial initiatives in collaborative institutions and projects.

I should note that although the views expressed here derive in large part from my colleagues at Bellcore, they really are my personal views.

Economic growth and industrial competitiveness come from the combination of an expanding base of scientific and technical knowledge, a pool of technologists able to convert that knowledge into industrial infrastructure and products, and a business atmosphere that encourages risk taking and long-term investment. Active industrial/academic collaborations, encouraged by Government policy, can significantly enhance the respective strengths of the collaborators and the economic competitiveness of the United States.

Both industrial and university research are intended to have an economic payback, but they differ in the immediate beneficiary and, therefore, who pays for the research. If the cost of the research is justified for the benefit it brings to one company, that company may sponsor it on its own, or a few companies may share the cost. Industrial research is mission-oriented, driven by a competitive environment. It tends to avoid nonappropriable research, which is research essential for advancing a technology base on which product development rests, but which does not offer a unique competitive advantage to anyone. A considerable portion of basic research is of this kind, particularly since it requires early and extensive interaction with a large research community. Government and industrial funding of nonappropriable university research can help to advance industrial competitiveness over the long term, the benefits of which flow to society as a whole.

University research creates a mosaic of knowledge that underpins a wide range of industrial and commercial activities. It is conventionally done by individuals or small groups gathered around professors. However, and especially in engineering fields, the total research value, and funding, might be greater if these groups shared a common vision and worked more closely with one another and with industry. Many universities have recognized this and are opting for coordinated research centers with direct participation by industrial representatives in defining and advancing the key projects. Industry is sympathetic to university research that is coordinated, focused on industrial interests, offers opportunities to get to know students, and enjoys a significant level of Government support.

Columbia University's CTR is notable for the strong voice its industrial affiliates have in the choice, direction, and execution of projects. We anticipate a significant future impact on the information networking infrastructure of the United States from the CTR project.

In summary, industrial research has a narrower set of beneficiaries and sponsors and is more product and business strategy oriented, while university research has a wide set of beneficiaries and is more speculative and fundamental. It has the specific responsibility of educating students and preparing them for fruitful careers.

Industry/university collaboration in the communications area steers university research and student interests toward those areas where new knowledge is needed for tomorrow's industries, which will be information-based industries needing ubiquitous access to databases and computing resources.

ERCs, as I suggested, aren't the only useful format for university/industrial research collaboration. There is tremendous diversity in the forms of such collaboration and value in having diversity. Collaboration includes individuals working together on their own, internships and summer jobs for students, adjunct faculty appointments from industry, visiting scholars, technical visits and exchanges, recruiting visits, industrial affiliates programs, contracts for specific work by university researchers, and sponsored research, in addition to research centers. Universities and industries are still struggling to define the best formats for the larger and more formal programs, and primarily for industry funding. It would, in my opinion, be prudent for Government policy to encourage a number of collaboration formats.

Special university/industrial research relationships outside of the usual university and industrial structures can also be successful vehicles for university/industry research collaboration. One interesting example is the National Institute for Scientific Research, INRS, in Montreal, sponsored jointly by Bell Northern Research and the University of Quebec. Principal investigators at INRS hold professional appointments at the University and have some teaching responsibilities. INRS is one more model for a technology transfer conduit between university and industry that Congress may wish to consider.

Mr. THORNTON. Dr. Weinstein, you are at a point in your testimony where you're about to make recommendations for Government funding.

Dr. WEINSTEIN. Yes.

Mr. THORNTON. And we will want to hear those recommendations. We do have the formal written testimony before us, and it will be made a part of the record.

However, we now have a series of votes, at least two votes. We have five minutes to make one and then five minutes for the next, and so I must at this point again declare the committee in recess. We will begin again at 15 minutes until one o'clock. Thank you for your testimony.

Dr. WEINSTEIN. Thank you.

[Whereupon, the subcommittee was in recess.]

Mr. THORNTON. Dr. Weinstein, you are about to make your recommendations for Government funding. And let me say for all of our witnesses that this Member reads every word that is submitted to the committee, and the staff analyze it and pay a great deal of attention to the questions and answers and to the work that you all have done.

The flurry of activities in which we leave and go vote should not belie the fact—and you all, as learned men, certainly know that for five minutes or ten minutes of actual appearance, that many hours of diligent study and work are required. Your testimony is very much a valued part of this committee's deliberation on a most important subject, perhaps the most important subject facing this

country as we go through this final decade of this century, as to whether we will be able to enter the next century in a position of having the military strength necessary to protect us, the economic strength on which to build a foundation for national security, and all of that in order that we may be the greatest country on Earth in terms of human values.

Your testimony is much appreciated and we look forward to your recommendations, Dr. Weinstein.

Dr. WEINSTEIN. Thank you.

I would like to close with some recommendations.

I strongly support the NSF programs for engineering research, both the smaller grants and the programs for NSF's Engineering Research Centers. I would urge Congress to consider funding the ERCs on a longer-term basis than NSF can now afford. This would assure that the ERCs are committed to building major, longer-term foundations for future technology rather than smaller, more salable research products. For the long-term research that will have the largest impact on future economic activity, I believe that seed money is not enough.

I also applaud NSF's practice of supporting research communities, such as stimulating and granting financial aid to key workshops. The benefits in defining research areas and furthering the human relationships among researchers in industry and academia needed for collaboration and technology transfer are large.

To augment the existing Federal funding mechanisms which already do these things, at least to some extent, I believe there are a number of creative possibilities that deserve further exploration within a comprehensive plan, including the following:

One, grants for science collections in high school and public libraries and museums, as well as for electronic access of those libraries to scientific/technical databases associated with both academic and industrial laboratories.

Mr. THORNTON. Please continue.

Dr. WEINSTEIN. Connection to the Internet or its proposed successor, the National Research and Education Network, might specifically be funded, as others have recommended. This would give a boost to student interest in and preparation for careers in science and technology, and would strengthen, in students' minds, the existence of a common research community between industry and universities.

Two, tax incentives for university/industrial cooperative initiatives, such as exchanges of scholars, setting up of joint venture laboratories, and building joint venture prototypes. I also recommend making the R&D tax credit permanent, as Dr. Bloch proposed.

Number three, providing more funds for scientific/technical scholarships and fellowships. We simply need more Americans in the engineering graduate schools.

Number four, as some defense-oriented Government research laboratories take on more civilian roles, turn them into collaborative research centers that encourage residences by faculty and industrial experts. There might be programs for financial support of short-term residences, e.g., one week sabbaticals for industrial and academic researchers in these Government laboratories.

Thank you for the opportunity to appear before you today. I hope that expectations for technology transfer from university to industry will focus on the development of intellectual power directed toward industrial interests and building long-term foundations for future technology development. U.S. industrial competitiveness is, in the long run, anchored in the best and largest community of people capable of conceiving new technology and new products and services.

I will be happy to answer any questions.

[The prepared statement of Dr. Weinstein follows:]

TESTIMONY

OF

STEPHEN B. WEINSTEIN

DIVISION MANAGER, SYSTEMS INTEGRATION RESEARCH

BELLCORE

ON

BASIC RESEARCH IN INDUSTRY AND UNIVERSITIES

BEFORE THE SUBCOMMITTEE ON SCIENCE OF

THE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,

U. S. HOUSE OF REPRESENTATIVES

JUNE 20, 1991

My name is Stephen Weinstein, and I am the Division Manager for Systems Integration Research at Bell Communications Research's (Bellcore) Morris Engineering and Research Center in Morristown, New Jersey. I am a communications engineer with a PhD from the University of California at Berkeley. Bellcore is a research, software development, and systems engineering organization with 8,000 employees that is jointly owned by all of the Bell Operating Companies. Bellcore's mission is to support exchange and exchange access services offered by those Companies, and coordinate telecommunications national defense preparedness. My function is to manage applied research on the subject of future public network communication services needed to support emerging communication applications as described below, particularly addressing the interfaces between customer and public network equipment. My organization is part of a much larger effort at Bellcore to generate technical insights and technologies for creating a public network that will give users access in voice, data, and video media to each other and to a wide range of information providers, and which will support applications such as distributed classrooms, medical image exchange and consulting, multimedia information delivery, and personalized multimedia communication.

Bellcore places a high value on its interactions and collaborations with university researchers and their programs, and one of my responsibilities is to represent Bellcore on the Industrial Advisory Board of Columbia University's Center for Telecommunications Research (CTR). CTR is an Engineering Research Center supported by the National Science Foundation

(NSF) as well as by its industrial affiliates, including Bellcore. My Bellcore colleagues and I are closely involved with CTR's ACORN project in high-speed lightwave networking, which is an outstanding example of industrial and academic collaboration.

My further comments will address the following themes:

- I will attempt to point out the contrast between the economic benefits derived from industrial research and academic research. Both seek to generate a potential for economic impact commensurate with the costs. Unlike the more proprietary economic benefits of industrial research, the benefits of university research are most likely to flow to a wide range of industries or to members of a research community. The most important products of university research are the attainment of scientific knowledge and the development of students into creative scientists and engineers. The combined results of these complementary research efforts underlie economic growth and industrial competitiveness.

  University research and industrial R&D are naturally complementary, but the forms for academic-industrial collaboration are still evolving. Engineering centers are a promising initiative.

Congress should consider long-term support for engineering centers, for information networking which links academic and industrial researchers, for access from high schools and public libraries to academic and industrial information resources, for exchange and internship programs, and for academic-industrial initiatives in collaborative institutions and projects.

I should note that although the views expressed here derive in large part from my experiences at Bellcore and incorporate ideas from my colleagues, they are my own views and do not necessarily reflect an official position of Bellcore.

COMMUNICATIONS RESEARCH IN INDUSTRIAL ORGANIZATIONS AND UNIVERSITIES

Economic growth and industrial competitiveness come from the combination of an expanding base of scientific and technical knowledge, a pool of technologists able to convert that knowledge into industrial infrastructure and products, and a business atmosphere that encourages risk-taking and long-term investment in the generation of knowledge and education of skilled people. Research at universities and in industry is similar in some respects, but different and complementary in others. Active industrial-academic collaborations, encouraged by government policy, can significantly enhance their respective strengths and the economic competitiveness of the United States.

Both industrial and university research are intended to have an economic payback, but they differ in the immediate beneficiary, and therefore, who pays for the research. If the costs of the research is justified for the benefit it brings to one company, that company may sponsor it on its own, or a few companies may share the cost. Industrial research is mission-oriented, driven by a competitive environment. It has tended to turn away from individual research and more toward team projects focused on common goals, with well-defined business potential in mind. Highly trained individual participants have roles appropriate for their specializations, but the projects are larger, more costly, and more "applied" than research typically associated with one or two individuals. Break-throughs happen occasionally, but most technical advances, and the economic benefits flowing from them, come from incremental improvements in materials, processing, and products, work that is more development than research [1].

Industrial research has a significant payback, and an industry that abandons it imperils its market leadership. Industrial researchers help generate a strategic vision and a knowledge base for making informed decisions where investments in technical infrastructure should or should not be made. They probe the implications of major technical changes o "paradigm shifts" such as, in the communications field, lightwave networks, very high speed switching of small packets of data, and personal communications to wireless telephones and palm-

sized data and visual terminals. They compare technical alternatives and build research prototypes to overcome obstacles and convince others that revolutionary technology is realizable and forecasted performance is achievable.

Industry is motivated to avoid "non-appropriable" research, which is research essential for advancing the technology base on which product development rests, but which does not offer a unique competitive advantage to anyone [2]. A considerable portion of basic research is of this kind, particularly since this type of research requires early and extensive interaction with a larger research community, which makes it difficult to make the research result proprietary. Government and industrial funding of non-appropriable university research, however, can help to advance industrial competitiveness over the long term.

University research is driven more by individual interests. In general, it creates a mosaic of knowledge that underpins a wide range of industrial and commercial activities, rather than addressing particular industrial problems in a coordinated fashion. I believe it is to the advantage of universities to concentrate on long-term basic research, the non-appropriable, research referred to above, and to the training and education of students. This does not deny the value of private consulting and entrepreneurial initiatives by faculty members, who are, in these roles, part of industry.

It is not unusual, within the same academic department, for groups under different professors to work on related aspects of a larger problem without much coordination. These groups are not isolated; they are active in their respective research communities, reach out to industrial sponsors and collaborators, and sometimes spawn entrepreneurial spinoffs [3].

However, and especially in engineering fields, the total research value (and funding) might be greater if these groups shared a common vision and worked more closely with one another and with industry. Many universities have recognized this and are opting for coordinated research centers with direct participation by industrial representatives in defining and advancing the key projects. Industry is sympathetic to university research that is coordinated, focused on industrial interests, offers opportunities to get to know students [4], and enjoys a significant level of government support [5]. Columbia University's CTR is notable for its organization with a strong industrial voice in the choice, direction, and execution of projects. In addition to membership on CTR's Industrial Advisory Board, participants in the flagship ACORN project sit on its Project Management Committee and take part in detailed work of its various task forces. Affiliates are encouraged to send visiting scholars. Despite the difficulty of achieving consensus among the industrial participants, the project has moved forward and we receive satisfaction from its educational and knowledge-generating accomplishments. We anticipate a significant future impact on the information networking infrastructure of the United States.

States are also funding such centers, illustrated by New York State's support for the Center for Advanced Technology in Computer Applications and Software Engineering (CASE [6]) at Syracuse University, and the Center for Advanced Technology in Telecommunications (CATT) at Polytechnic Institute of New York. New Jersey supports the Photonics and Electronic Materials center (POEM) at Princeton University, and the Wireless Information Networks (WIN) Laboratory at Rutgers University.

The engineering centers are not entirely dedicated to large projects, but a flagship project builds visibility for a center, which is useful not only to attract industry participation and government funding, but also to interest students and non-technical outside observers. In this sense, the engineering centers outwardly resemble industrial team research, but differences remain in the much broader set of beneficiaries and the retention of elements of individual faculty members choice and direction.

In summary, industrial research has a narrower set of beneficiaries and sponsors and is more product- and business strategy-oriented, while university research has a wide set of beneficiaries and is more speculative and fundamental. It is also more tolerant of individual faculty interests (notwithstanding their association with a research center), and has the specific responsibility of educating students and preparing them for fruitful careers. Industrial-university collaboration in the communications area steers university research and student interests toward those areas where new knowledge is needed for tomorrow's

industries, which will be information-based industries needing ubiquitous access to databases and computing resources. The worlds of computing, information networking, and multimedia applications envisioned by the proponents of the National Research and Engineering Network [7] and by projects such as CTR's ACORN will not only be infrastructure for American industries, but will be highly productive industries in themselves.

FORMATS FOR UNIVERSITY-INDUSTRIAL RESEARCH COLLABORATION

There is tremendous diversity in the forms of university-industrial research collaboration and value in having such diversity. Collaboration includes individuals working together on their own, internships and summer jobs for students, adjunct (industry-based) faculty appointments, visiting scholars, technical visits and exchanges, recruiting visits, industrial affiliates programs, contracts for specific work by university researchers, sponsored research, and research centers such as those described earlier. Universities and industries are still struggling to define the best formats for the larger and more formal programs, and particularly for industry funding. It would be prudent for government policy to encourage a number of collaboration formats.

The key to successful research collaboration is in a complementary relationship, with the university and industrial partners each filling an unmet need of the other. In contrast to the popular conception of technology transfer from university research, experimental

components often go from industry to university. For example, in Bellcore's relationship with CTR, some experimental devices for lightwave networks, and chips for high-speed digital communication, may be transferred from Bellcore to CTR. CTR would use them to conduct the fundamental research on future lightwave network architecture and management that is outside of the present scope of Bellcore's applied research activity, but important to the long-term competitiveness of the U.S. telecommunications industry.

Bellcore, among others, would benefit from new knowledge about networking architectures made possible by evolving optoelectronic technologies, and from the orientation of faculty and students toward the needs of our industry. This is, in my opinion, a successful example of non-appropriable research conducted at a university complementing an industrial research program.

Special university-industrial research relationships outside of the usual university and industrial structures can also be very successful vehicles for university-industry research collaboration. One interesting example is the National Institute of Scientific Research (INRS) in Montreal, sponsored jointly by Bell Northern Research and the University of Quebec [8]. Principal investigators at INRS hold professional appointments at the University and have some teaching responsibilities. INRS is one model for a technology transfer conduit between university and industry. The better known model, less tightly tied to academic research, is a consortium of several industries, such as the Microelectronics and

Computers Corporation (MCC) or the Semiconductor Research Corporation (SRC) [9].

Strong industrial affiliates programs also provide extensive access by industry to academic research.

RECOMMENDATIONS FOR GOVERNMENT FUNDING

I strongly support the NSF programs for engineering research, both the smaller grants and NSFs program for Engineering Research Centers (ERC). I would urge Congress to consider funding ERCs on a longer-term basis than NSF can now afford. This would assure that the ERCs are committed to building major, longer-term foundations for future technology, rather than smaller, more salable research products. For the long-term research that will have the largest impact on future economic activity, seed money is not enough.

I also applaud NSF's practice of supporting research communities, such as stimulating and granting financial aid to workshops. The benefits in defining research areas and furthering the human relationships needed for collaboration and technology transfer are large. Congress should have available to it a systematic and continually updated review of research communities and their long-term importance to American economic competitiveness.

To augment the existing federal funding mechanisms, I believe there are a number of creative possibilities that deserve further exploration, including the following:

(1) Grants for science collections in high school and public libraries and museums, as well as, for electronic access of those libraries to scientific/technical databases associated with both academic and industrial laboratories. Connection to the Internet or its proposed successor, the National Research and Education Network, might specifically be funded, as expert bodies have recommended [7]. This would give a boost to student interest in and preparation for careers in science and technology, and would strengthen, in student's minds, the existence of a common research community between industry and universities.

(2) Tax incentives for university/industrial cooperative initiatives such as exchanges of scholars, setting up of joint venture laboratories, and building joint research prototypes.

(3) Providing more funds for scientific/technical scholarships and fellowships.

(4) Converting some defense-oriented government research laboratories into non-defense collaborative research centers that encourage residences by faculty and industrial

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experts. This might include financial support for short-term residences, e.g. one-week "sabbaticals", as well as longer terms.

CONCLUDING REMARKS

I appreciate the opportunity to offer my views to the Subcommittee as one of many contributions to Congressional consideration of ways to strengthen university-industrial scientific collaboration and technology transfer. I hope that expectations for technology transfer will focus on the development of intellectual power capable of addressing industrial interests and building long-term foundations for future technology development. U.S. industrial competitiveness is in the long run anchored in the best and largest community of people capable of conceiving new technology and new products and services.

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Mr. THORNTON. And we will have some questions. Thank you very much for your excellent testimony.

Dr. Acampora from Columbia, we're delighted to have you. Your testimony, as prepared, will be entered into the record of this hearing, word-for-word, as you have set it out. We would appreciate your making an effort to summarize that testimony in order that we may get to the questions.

Dr. ACAMPORA. I want to thank you for—my gratitude for the opportunity to be here today and to share with you my views on this important subject of the role of basic research in economic competitiveness.

As the director of an Engineering Research Center, it's a topic with which I have recently developed considerable familiarity and, as I'm sure you're all aware, one of the goals of the Engineering Research Center program when it was established seven years ago was to encourage university/industrial cooperation in research and also in education as an experiment in economic competitiveness.

I would like to confine my comments in these opening remarks to three topics. First I would like to provide some further personal insights on the rationale behind the ERC program, and then I would like to share with you some of the ERC success stories coming out of the Center for Telecommunications Research at Columbia, and finally, I would like to address certain issues which might tend to impede further gains.

In explaining the rationale behind the ERC program, I'll use the field of telecommunications as a representative example. Telecommunications is an industry where breakthroughs in enabling core technology, such as photonics, such as high-speed microelectronics, are offering significant potential for new commercial products and service offerings. But it's also an industry which is subject to fierce competition, both domestically and internationally. Under these circumstances, the tendency of the industry is often to reduce costs and to shore up profitability. Sometimes this is done by downsizing the long-range vision and long-range research program, redirecting the surviving developing efforts toward reusing existing products.

Many in the industry recognize that this focus on the short term might be compromising long-term strategic advantage, but are powerless to correct the situation, especially if they don't know whether their own particular company will still be in business two or three years downstream.

An ERC devoted to telecommunications therefore fills a critical void. It provides a forum for the creation and exchange of new knowledge and technology, it represents an opportunity for industry to provide input and direction to a major research initiative at modest expense, and it produces a sound technological platform to facilitate more rapid commercialization of new opportunities.

Some examples would be instructive. At the Columbia Center for Telecommunication Research, we initiated in 1990 a program known as Project ACORN. ACORN first saw light of day at a meeting of one of our industrial advisory boards, at which time I proposed that rather than continuing our ongoing collaboration with individual people, from individual companies, on many smaller projects, we instead might turn our attention to conducting a major undertaking to rapidly promote the state-of-the-art in one particu-

lar area; in this case, technology, management techniques, and applications for very high-speed, all-optical networks.

I asked for the assignment of one person on a part-time basis from each of the companies to plan such a program and to write a proposal. Fifteen companies sent representation to participate in this planning phase, and over a six-month period we, in fact, developed a proposal for a rather long-range research program.

Ten companies are now participating in this program, providing funding, equipment, and most importantly, people. It's a true collaborative activity. Through its frequent and regular meetings, ACORN has provided, first, an opportunity for industry to gain exposure to significant new technological opportunities; second, it has provided an opportunity for those of us in academia to gain some exposure to some practical issues and some real-world constraints; and third, to provide an opportunity to get our students involved and interacting with industry at all degree levels.

An experimental test bed is now under construction and plans are developing to involve other academic departments at Columbia University—the biology department, the chemistry department, radiology, law and education—in exploring new high-speed computer and multimedia applications that would use the unique capabilities of this experimental test bed.

Let me give a second example involving portable computing. Two years ago we embarked upon a major new program in collaboration with one of our industrial participants involving small electronic "notebooks" which might be capable of accessing large databases over high-speed radio links. So as an example, if one had his or her office electronically organized—documents on line, correspondence on line, manuscripts on line, the type of information with which we normally operate while we're in our office—and if we had one of these small, portable, hand-held notebooks which accepted a stylus-like input and provided very high quality graphical output, then one would enjoy the appearance of a portable office. One would be able to access files, manipulate files, edit correspondence, basically conduct one's normal business workload from wherever one might happen to be within the region served by this capability—a campus, a small building, something like that.

Software technology has been transferred from this project to industry, and today we're considering the organization of a follow-up program which would offer ubiquitous, wireless computing as a service over the entire Columbia campus.

Finally, what are some of the issues. I've already mentioned the short-term focus of many companies within the industry. Without commenting on the necessity or the desirability of this, let me state emphatically that it does have the effect of increasing volatility, the volatility of industrial support, and interaction with programs such as the ERC program.

Second, it would be highly desirable from my perspective if scientists and engineers from industry were to rotate through universities for periods of three months to a year. Although such rotation is relatively commonplace in Europe and in the Far East, where returning employees are often given a sizable raise or even a promotion to reflect their increased value to the company, there appears

to be little incentive for American employees to seek such internships.

Finally, there is a certain perception, real or imaginary, that precompetitive collaboration among companies in the same or related industries, even when conducted on the neutral territory of a cooperating university, is somehow to be discouraged.

I hope that my appearance here today will be helpful in promoting greater university/industrial cooperation in research and in education, and I'm prepared to respond to any questions which you might have.

Thank you.

[The prepared statement of Dr. Acampora follows:]

TESTIMONY BY PROFESSOR ANTHONY S. ACAMPORA
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JUNE 20, 1991

The National Science Foundation established the Engineering Research Center (ERC) program six years ago to promote economic competitiveness by fostering university/industrial collaboration in engineering research and education.

The program is characterized by three unique features. The first is cross-disciplinary research. The intent here is to identify a small set of emerging opportunities and then assemble a team of researchers with the necessary blend of skills to create a solid technological platform from which innovations and technologies can be transferred for subsequent commercialization. The second feature is strong industrial participation in the research program, involving input to the direction of the research, collaboration on selected projects, and extensive exposure to students. Finally, students are to be involved in the cross-disciplinary research programs at all degree levels--BS, MS, Ph.D. in order to produce graduates with backgrounds and skills matched to evolving industrial needs.

As many of you on the panel are aware, there are currently eighteen such centers spread throughout the country, including those centers at the University of Illinois, Duke University, and, or course, our own at Columbia in New York State.

I'd like to begin by describing the rationale for an ERC, using the telecommunications industry as an example. Next, I will present two examples of how university/industrial cooperation can work. Finally, I will conclude by mentioning several issues--obstacles in the path of further cooperation, technology transfer, and rapid commercialization of research innovations.

Telecommunications is a major enabling factor driving American industry. Both the manufacturing and service sectors are critically dependent upon availability of state-of-the-art telecommunication services. Networks that exploit leading-edge technologies are essential to these industries for accessing and exchanging information, facilitating interactions with clients and customers, responding to dynamically varying market conditions, enhancing worker productivity, and remaining economically competitive in a global environment. Furthermore, the telecommunications industry, *per se*, is one of the largest and most critical components of the American economy employing about two million people and generating annual gross revenues in

excess of $100 billion.

This country's acknowledged preeminence in the field of telecommunications is starting to buckle under the pressure of intense competition, and rapidly advancing technical opportunities require that fundamental research of the highest quality be pursued and applied to retard and reverse this erosion. A study of the nation's telecommunications equipment industry, recently completed by the Commerce Department, has found that the U.S. has lost its competitive edge for consumer-oriented products such as telephones and facsimile machines, and is losing market share for business and telephone company equipment. From 1984 to 1987, the American share of the world market for voicegrade PBXs fell from 29% to 26%; for datagrade PBXs from 100% to 36%; for fiber-optic equipment from 75% to 50%; and for data modems from 49% to 37%. Among the reasons cited for this decline are an inadequate educational system and a failure to quickly incorporate technical breakthroughs into new products.

The decade of the '80s has produced dramatic advances in the key telecommunications-enabling technologies of VLSI, lightwave devices, and software, a brief sampling of which might include: sophisticated VLSI operating at clock speeds measured in hundreds of megahertz; new materials for higher speed digital electronic and lightwave devices; narrow linewidth single-mode semiconductor lasers; semiconductor and erbium-doped fiber-optic amplifiers; extremely broadband passive optical components and fabrication techniques; powerful desktop workstations; distributed operating systems and data bases; and object-oriented programming and knowledge representation.

Research is needed to remain at the vanguard of these explosive developments, to harness and guide these developments toward telecommunication applications, and to create innovative new telecommunication system architectures and approaches which utilize these advancing technological capabilities to the greatest possible extent.

Telecommunications is an extremely competitive industry. The AT&T divestiture in 1984 has dramatically increased competition among common carriers at the local, regional, and national levels. Competition among American and foreign telecommunication equipment vendors is keen. Technological advances are permitting large, sophisticated telecommunication users to create and operate their own private networks if the demanded services are not provided at an affordable level by local telephone companies.

It is perhaps understandable that the response of the telecommunications industry to these enormous competitive pressures has been to adopt a market-driven strategy which seeks to improve short-term profitability by reducing research and development (R&D) expenditures and which attempts to direct that reduced R&D effort toward the solution of immediate problems at the expense of a longer-range, strategic platform. While such a strategy may be driven by economic necessity, many (if not most) leaders within the industry recognize that such short-term expediency may very well compromise long-range preeminence.

The telecommunications industry in the United States, from the manufacturing to the common carrier segment, is clearly at a critical juncture. A national research center, focused on telecommunication networks and services, is needed to provide knowledge, innovative systems architectures, and technical sophistication beyond the planning horizons of the industry.

In the little over five years of its existence, the CTR has created just such a longer-range strategic forum for the telecommunications industry in which new technical and market opportunities are discussed, technological information is exchanged, collaborations are formed, and new systems and devices are transferred from the university to the commercial sector. By pooling the financial support provided by the industrial participants, leveraging this with support provided by the NSF, and supplementing both with laboratory facilities and expertise developed via past and other current grants, the CTR permits individual companies from the industry to provide input and direction, and to enjoy the benefits of a major strategically-focused telecommunications research program. Not only does industry enjoy early access to research breakthroughs and accomplishments, but it also enjoys exposure to new system concepts, technologies, and ideas for subsequent commercial application. Equally important is the two-way interaction and exposure between industry and students.

The ACORN program, a project initiated in early 1990, is a successful example of university/industrial cooperation which I'd like to discuss in some detail. ACORN (Advanced Communications Organization Research Network) has brought together nine companies to focus on commercial opportunities in high-speed fiber-optic networks and high-speed applications involving supercomputer interconnection and distributed processing. The participants include AT&T Bell Laboratories, Bellcore, GTE, NEC, Northern Telecom, NYNEX, Philips Research Laboratories, SBC Technology Resources, Inc., and Teleport Communications Group.

The idea for such an ambitious collaborative undertaking arose in early 1989 during meetings of CTR investigators. The objectives were to leapfrog current international standards discussions on broadband Integrated Services Digital Networks (ISDN), to demonstrate that our lightwave focal project goals were not idle conjectures but were, hopefully, capable of realization, to push the state-of-the-art as far as possible, and to show that broadband applications would be enthusiastically accepted by the user community. Our proposal would be targeted directly at the telecommunications industry and would be oriented toward the lightwave networks of the 21st century, along with exploratory broadband business and residential applications.

The notion of a joint project involving CTR and a group of its industrial participants was presented at the Spring 1989 meeting of our Industrial Advisory Board, and was enthusiastically received. The board suggested that a detailed proposal be developed, in collaboration with the industrial participants, and submitted to the participants for individual approval by the fall of 1989. Following this advice, a series of all-day meetings convened during the summer of 1989 to spell out the goals of the ACORN project, identify research to be carried out, prepare a schedule, and specify those applications on which to focus. In addition to CTR staff and principal investigators, representatives of up to 15 affiliate companies attended these plenary meetings. Smaller subgroups met to define the applications of primary interest and the research to be conducted. This intense activity culminated in a detailed proposal, submitted to interested affiliates in October 1989 for their approval.

The proposal was quickly approved by ten affiliates, and work on ACORN was formally begun in January 1990. Reactions to ACORN from industry include statements from Robert Pfeffer, Vice President of Fiber Systems at BNR, who has said, "ACORN represents an essential investment in the search for future technology to expand the capability, capacity, and benefits of today's technology." Paul Henry, Director of Communications Systems Research at AT&T Bell Laboratories, said, "ACORN is an exciting research effort in lightwave communication networks and, in addition, students benefit from timely exposure to an important field."

A second example of successful university/industrial collaboration involves our Electronic Notebook project, a strongly cross-disciplinary effort initiated by way of a larger project-specific IBM grant. The goal of this project is to create a portable computing environment in which a high-speed

radio channel is shared by a large number of small portable "notebooks," providing high speed, packet-oriented, Local Area Network-like services between the notebooks and a base station connected to a wired network. Such a system would enable each portable notebook to access the processors and data base resources of the wired network from anywhere within a large building or small campus. The notebook would serve, essentially, as a "paper-like" input/output device, accepting simple stylus-driven commands, producing high-quality graphic displays, and permitting remote computation or manipulation of files. As an example, the notebook could serve as an electronic book enabling access to libraries and picture archives, or as a portable office by enabling access to (and processing of) electronically-stored manuscripts and correspondence.

This project has produced distributed data base and remote software which has been transferred to IBM, and has produced a new media access protocol (also transferred to IBM) for a broadband radio-based Local Area Network. Dr. David Bantz, Manager of Portable Systems at IBM's Thomas J. Watson Research Center, has stated that "our collaboration--the combination of our complementary strengths--has already had a strong impact on IBM's strategy in portable computing. The demonstration of the feasibility of mobile, connected computing may have advanced our product plans by as much as a year, and has focussed attention on the key aspects of the system that will require further work. This focus is very valuable to us. Let me emphasize again my company's thanks for CTR's energetic, practical and high-quality contributions to the student electronic notebook project."

Both of these cases demonstrate that obstacles to university/industry cooperation can and are being surmounted with outstanding results. Obstacles, however, do exist, and it is my hope that by participating here today, I can shed some light on these issues.

Successful university/industrial interaction and collaboration is a two-way street, involving opportunities and obligations on both sides. Universities gain exposure to meaningful long-term issues, along with the opportunity to direct their scholarly and intellectual pursuits toward accomplishments that have good prospects for subsequent commercial and product offerings. At the same time, academics have the responsibility to socialize their findings to a broad audience, extending beyond their immediate academic community, where the strategic significance of their work might be recognized and applied. Similarly, industry enjoys the opportunity to provide input and direction to strategically

focused research programs. At the same time, industry has a responsibility to support the research program with funding, equipment and people, and to develop a better understanding of the long-term opportunities represented by today's research innovations.

Industry is perennially focused on the short-term--the next quarterly profit report, the end-of-year balance sheet. Corporations, therefore, too often discontinue cooperation with universities when faced with competitive pressures and tight budgets. Many projects require a long-term investment before results are achieved. Financial volatility makes partnerships with corporations problematic.

Another issue concerns assignment of industrial scientists and engineers to cooperating universities. In Europe and the Far East, business executives, scientists and engineers are frequently rotated for a year at a time to a university to enhance their sophistication and knowledge of technological advances. It is a prestigious assignment, and the employee may receive a promotion upon return. In this country, there is no monetary or professional advantage for a corporate employee to rotate. In fact, it is often the "expendable" staff that undertake these assignments. As a result, employees try to avoid assignments with the attendant stigma.

A third issue involves the perception, real or imagined, that collaboration among companies in the same or related industries, even when conducted on the "neutral territory" of a cooperating university, is discouraged by legislation and governmental policy.

It is my opinion that the U.S. government should develop enabling legislation and policies addressing these issues and problem areas. Programs are needed which (1) further encourage universities to seek interaction and partnerships with industry, building upon experiences gained through the ERC program; (2) encourage industry to adopt a longer-term planning horizon which strategically embraces university research accomplishments; (3) encourage rotating assignment of employees from industry to academia, and vice-versa; and (4) clarify the permissibility of industrial collaboration in the pre-competitive phase of a new technology or innovation.

Programs which accomplish the above will further enhance university/industrial interaction, produce an increasing number of success stories such as those illustrated above, and generally enhance our nation's economic competitiveness.

Thank you for the opportunity to speak here today. I hope my comments have been useful and constructive.

Mr. THORNTON. Thank you very much. I do understand that you have a requirement to leave before two o'clock, so I'm going to address—

Dr. ACAMPORA. Two-fifteen.

Mr. THORNTON. Oh, very good. Then we'll have time to ask for an interplay of the panelists on the questions, and I think that's very appropriate.

I was very interested in your discussion of the ACORN project dealing with advanced communications organizations, research, because the Chairman of this subcommittee has been taking a leadership role in providing for the development of fiber optic networks as a means of developing an infrastructure in America to make us competitive. I would be interested in any further suggestions you might make as to the significance of this kind of infrastructure in the future world.

Dr. ACAMPORA. I can reply to that from two perspectives. First, from the technological perspective. I think that in the field of optical communications, we've only now seen the tip of the iceberg. Optical communications are being used basically as upscale replacements for copper, for radio links, for the type of point-to-point telecommunications that is characteristic of today's telecommunications infrastructure.

It may turn out that is the ultimate home for optics, but I tend not to believe that. I think the opportunities presented in optical communications go far beyond replacement for what we currently do. When we speak of replacements, what we're currently doing, what it generally means is there's an economic advantage to installing optical transmission links to replace radio or copper-based links that are in service today. I think that optics has an opportunity to offer significant new service potential, not just economically-justifiable replacement for an infrastructure that's in place, but totally new services.

Let me just give an example, while trying not to become too technical. One single strand of optical fiber, single-mode optical fiber, has a potentially addressable bandwidth, which is measure of how much information can be carried, of 100,000 gigahertz. That's a technical term, but don't worry too much about what a gigahertz is. Remember the figure 100,000.

Mr. THORNTON. It's a lot, isn't it?

Dr. ACAMPORA. It's a lot.

The entire radio spectrum that's measured by the Federal Communications Commission today, covering all of our AM transmission, FM transmission, satellite communications, cellular radio, all of our radio services occupies a spectrum of 30 gigahertz. One strand of glass has a spectrum 3,000 times wider. When we learn how to open up that spectrum and tap into it, then I think we will see the era of true, multimedia pervasive, broad-band telecommunications with unlimited types of potential.

Mr. THORNTON. The reason I wanted to pursue that, as well as some of the other suggestions that you and other witnesses have made, is that I believe not only is it important that we have a strategy, or a comprehensive plan, but that we pay attention to the details, because it is on the details that the success of our programs will ultimately be measured.

For example, Dr. Weinstein, in your testimony, among your recommendations, the grants for high schools and moving electronic access into earlier education is a detail, but it is, it seems to me, an important detail. Would you like to comment further on that part of your suggestion?

Dr. WEINSTEIN. Yes, I would. Libraries, as you know, are struggling to automate, public libraries on very thin budgets, and high schools and public libraries, and they have been organizing locally sometimes, on a county-wide basis, sometimes a little wider than that. But to really have access to information resources that I think would inspire students and inspire their interest in technology, I think they need access to some of those resources that people are talking about for the research networks that would link people in our organizations. I think we have to make that available to the public at large in some degree, and for a not very large investment, in my opinion, there could be a very useful access provided to a large number of public libraries and high schools.

Mr. THORNTON. An element that seemed to me to span the testimony of each of the witnesses was the concern about improving ways of forming collaborative efforts, joint efforts, the concern about restraints of Government policy, whether of antitrust laws or proprietary laws relating to proprietary information, securing the driving force of patent protection. All of these things, it seems to me, every one of you have suggested that we need to pay some attention to that, the restraints that cause an American company to more readily enter into a contract with an overseas firm than to go down the street and enter into a collaborative agreement with another firm in this country.

Am I correct? Do each of you believe that this is something that we need to move in the direction of relieving restraints on cooperative ventures?

Please begin, Dr. Weinstein. I believe your suggestion of tax incentives for university/industrial cooperative initiatives was an example of something, a "carrot" approach to encouraging this.

Dr. WEINSTEIN. That's more an incentive than a constraint, of course.

Mr. THORNTON. Yes.

Dr. WEINSTEIN. We do conduct research collaborations with other companies under the National Collaborative Research Act of 1984. So far it has allowed us a fair range of latitude in doing the sorts of precompetitive research that we want to do with other industries.

But I think that if you want to expand this further to really stimulate the development of products and services, there will have to be consideration of what it would take to allow perhaps moving up the chain a little bit, from pre-competitive research to something a little more closely connected to ultimate services and products.

Mr. THORNTON. The Engineering Research Centers have been a real success story, it seems to me. They illustrate the kind of activities that we should be engaging in. As you say, Dr. Solberg, they are a new and different approach in several ways. They are specifically aimed at the issue of becoming industrially competitive, are they not?

Dr. SOLBERG. They are. That's correct.

Mr. THORNTON. Can we learn some lessons from this that might be applicable to other operations of government?

Dr. SOLBERG. Well, exactly. I think it was started small as an experiment, with considerable fear over the uncertainties that attended such a new way of doing business. Most of those fears, in my experience, have been groundless. We've learned a lot from this. The fear that university professors have that they would somehow be dragged into the dirty details of business and somehow contaminated in that process, and the fears that the industry people had, that the universities would run off and do strange things that were of no use to them, proved to be mythical.

Once we got together in the same room and started talking about common problems and so forth, it became quickly apparent that we had a lot to talk about, we should have been talking all along. So I think that's probably the primary lesson from this experiment.

Mr. THORNTON. Dr. Gjostein, a matter which is of great concern to me is that I was told the other day by a Member of Congress, whose statements are, in my experience, always soundly based, that if fleet sales were left out of the market analysis, that during this last year Japanese automobiles accounted for more than 50 percent of all cars sold in America. I think there are enormous pressures upon our automobile industry.

I take very seriously your suggestions that we need to find ways of addressing research to meet present needs to remain competitive. Your written statement to that effect is much valued. Do you have any other suggestions that we might do in order to maintain the viability of an industry which is critical to American economic prosperity?

Dr. GJOSTEIN. Yes. I was stressing that. We need to have more research, I think, oriented towards civilian industry needs. And a good example, for example, would be in the composites area, structural composites. The kind of work that's done for military and aerospace research is not the kind of research that we need for these materials for our industry, because we have to have low cost, very high reliability, in very high volumes.

One could reorient the research that's currently being carried out in these activities (that I referred to) that would be much more directed towards those three criteria that I mentioned—cost, reliability, and high production volume. So that we tend to favor that approach.

I'd like to comment also, if I might—

Mr. THORNTON. Please. Your comments and—

Dr. GJOSTEIN. —also on the other two questions that were asked.

I think one of the key elements that you see in the ERCs, a very positive element, and also that we've seen in our individual grants to faculty members, which as I mentioned is about 90 percent of our portfolio, that in each case we've seen the university participant seeking out what the needs are in industry, and in that way they become more familiar with our needs. They go back and formulate programs that are going to be more oriented towards our needs.

When we first started out some years back, there was a negative attitude, I think, towards universities. We thought that they wouldn't do that. But we've seen a remarkable change in that

sense and we're very pleased with that. We feel that we're working in real partnership with the universities.

Mr. THORNTON. Let me share with you that there was an equal reluctance on the part of some universities to be tainted by moving in the direction of entering into agreements with private sector firms, that this would somehow damage pure science.

Dr. Acampora, and then we'll come right back to you, Dr. Gjostein.

Dr. ACAMPORA. Yeah. Let me try to pick up on that. I enjoy a certain advantage that some of my colleagues perhaps do not, and that is that I spent 20 years in industrial research at AT&T Bell Laboratories prior to assuming my current position at Columbia University. And one of the advantages that we enjoyed in basic research at Bell Labs was close proximity to real relevant problems—relevant is the key word—among the entire spectrum of activities that we could become intellectually excited about as academics.

We can produce scholarly new knowledge and provide good material for lots and lots of doctoral dissertations, some of it is even meaningful. And I take great pleasure, and I think my colleagues are beginning to take great pleasure, in seeing the results of their efforts appearing not just in these scholarly archives and the technical journals and in the U.S. Patent Office, but in products and services. These ideas, these technologies, innovations, are now being embodied in something that is actually providing some value in the commercial sense and in the human sense to somebody else.

I think that our interaction with industry is helping us to focus our attention on those relevant problems. They're just as intellectually stimulating, they're just as scholarly, they provide just as good a foundation for doctoral dissertations, and they're useful as well. That's interaction with industry. We've benefited enormously from that type of interaction. It's more than just attracting industrial support for our research, but having that lively, day in and day out interaction that I believe has really caused our research to prosper.

Mr. THORNTON. It reminds me of the discussion between two faculty members about Socrates, one contending that he was a great scholar and the other saying "well, you know, he never published." Sometimes publication becomes the goal rather than solving needs.

Dr. Gjostein, I interrupted you because—

Dr. GJOSTEIN. As a matter of fact, I don't think the number of publications has gone down—

Mr. THORNTON. No, I don't think so, either.

Dr. GJOSTEIN. —at all. In fact, they may be different types of publications than they were in the past, but our program, in the few years we've been involved, has already generated, you know, several hundred publications.

Mr. THORNTON. I don't knock publications, either. I think it's very important to disseminate knowledge and to publish, but I think that you can do so in a way that is more directed perhaps than we—

Dr. GJOSTEIN. Also, I think the faculty members feel a real sense of excitement in working with industry, because they know their research is going to be used. Everybody gets excited when you know that something is going to be used finally.

Another comment I would like to make is on the working together in consortia amongst industrial partners. We feel very positive about that at the moment. We've got the auto-oil consortium, the automotive composites consortium, the battery consortium. All of these have been formed in the last few years after the Cooperative Technology Act[3] was passed. So I think we do not feel terribly restrained in that area at all.

Mr. THORNTON. Dr. Solberg, do you have a—

Dr. SOLBERG. I would like to point out one more thing. We have common experiences and I think we share the sense of excitement about what we've learned in the ERC and other similar kinds of experiences.

I wanted to point out, though, that there are only a few universities that have yet learned these lessons, and we're just at the beginning of the curve of transformation to this feeling we've expressed.

Mr. THORNTON. I agree with that, and consequently it becomes even more important, does it not, to try to look ahead and use some vision and making sure that the curve proceeds in a way that will be beneficial.

Dr. SOLBERG. Indeed.

Mr. THORNTON. Dr. Weinstein, do you have any other comments with regard to the questions the other witnesses have been addressing?

Dr. WEINSTEIN. I haven't said very much from my side about the collaboration with the Center for Telecommunications—

Mr. THORNTON. I would like to hear—

Dr. WEINSTEIN. —and perhaps I should say something.

First of all, we find that, over time, people at CTR, the faculty and the students, are speaking our language, and it's kind of an amazing transformation that we're—it's really a wonderful thing for us to have the same, you know, the same set of presumptions about the directions of technology and the things that ought to be worked on being worked on by faculty and students. This has been most gratifying.

Especially this project that we're referring to, the ACORN project, looking to greater exploitation of the potential of lightwave communications and proposing really a new paradigm in the way communications is done, maybe going back to older ideas about having analog systems instead of digital systems, revolutionary ideas. They seem to come back in new forms. These are things that can be extremely important for the generation even beyond the next generation. It's something that really will be very important for the infrastructure of the country, and people who are being prepared in this experience now at the university will be the people who will do it.

Mr. THORNTON. Francis Bacon wrote in Novum Organon, "It would be unsound and contradictory to suppose that that which has never been done can be done, except by means which have not yet been tried." We do learn from the past, but our vision and our expectation should not be limited by past experiences.

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[3]National Cooperative Research Act of 1986.

With that quotation, Mr. Chairman, I would like to recognize you to question the witnesses. This has been a most excellent panel.

Mr. BOUCHER. Thank you very much, Mr. Chairman. I appreciate your willingness to assume the duties of the chair, and I apologize to this panel of witnesses for the interruptions that you've had to endure. We have yet to convince the Speaker and the Majority Leader that they should organize floor votes around the schedule of this subcommittee. We tried, but we have yet to succeed in that mission.

Let me ask a couple of questions that relate to some fairly small subjects, but I think important ones. One of the things that this subcommittee has heard repeatedly in the course of our hearings this year is that universities have a dire need for new buildings in which to conduct their research. And I wonder, in the course of your collaborative work with the universities, if you can confirm that general statement, and if you can give us some sense of the urgency of that need and the magnitude of it, and Dr. Gjostein, let's begin with you, sir.

Dr. GJOSTEIN. Well, I would—In my travels around looking at various universities—and I get to visit quite a few in connection with the university research program—it's pointed out over and over again that there aren't sufficient facilities to do the kind of work that needs to be done. In many cases, it also reflects the educational component of the university. For example, there aren't enough computing resources within the school as well.

I'm aware also of the study done by the National Science Foundation, which shows—I forget what the number is, but it may be like 80 million or something is required to put the facilities back on par with what is really needed. So my own personal observations, without citing any specific example, is that there's a real need for improved facilities in the universities.

Mr. BOUCHER. How about with respect to state-of-the-art instrumentation? Do you sense a need in that area as well?

Dr. GJOSTEIN. Yes, right. We find often that the students, when they come into industry, are seeing new instrumentation, new computing techniques, et cetera, that they've not yet seen in their training period.

Mr. BOUCHER. If you had to prioritize the need between research facilities, meaning buildings, and new instrumentation, which would you rank the highest?

Dr. GJOSTEIN. Hum, that's a tough question. I guess I would rank instrumentation higher.

Mr. BOUCHER. It's interesting you would say that because that was the exact position the administration took this year in recommending no funding for research facilities modernization and recommending—I think the figure was what, $40 million?—$50 million, for instrumentation.

In the reauthorization of the National Science Foundation's programs, this subcommittee provided funds for both, with a little bit more for buildings than for instrumentation. But I'm very interested in your answer, that instrumentation probably would be a higher priority.

Do other members of the panel care to comment? Dr. Acampora?

Dr. ACAMPORA. Yes, I would like to comment on your question.

Given some experiences that we've gained at Columbia University, first with regard to buildings, or physical space, the existence of the Center for Telecommunications Research has caused the faculty in electrical engineering alone to grow by approximately 50 percent over the past six years, and the number of doctoral students that are enrolled in the program to also increase by approximately 50 percent. At the same time, the physical space has not increased at all. You can imagine the types of pressures that that would create.

In addition, we have new activities that are underway, new collaborative projects, such as the ACORN project that we discussed earlier, the Electronic Notebook project that was also discussed, and a myriad of other activities that need space above and beyond the normal research laboratory and office facilities. We need space to house visitors from industry as well, another new need.

We're very fortunate in that Columbia University has made a commitment to a new building, which hopefully will be completed and ready for occupancy in early 1992, which will provide us with 150,000 square feet of new additional office and laboratory facilities.

At the same time, the pressure, or the need for that new building, has grown so dramatically over the six-year period from when it was committed to when it will actually be completed and occupied, that that space is currently all allocated and we're still struggling to find yet additional space.

So the need for buildings is quite real, and as the Engineering Research Centers become more successful and more prominent, that need will grow.

With regard to equipment, not only is there a need for new state-of-the-art equipment to be housed within these new buildings and for our students to experiment with and for our research to continue on, but what's emerging as another critical need is the means to maintain the equipment that we have. As it turns out, we're sometimes—I'm not going to say often—but we're sometimes fortunate enough to procure grants to buy new equipment, and we're also fortunate enough to secure grants to maintain our research program and to provide support to our post-docs and to our graduate students and so forth. It's a rare grant that provides an allocation to maintain the equipment base we've already got, and we find that we're struggling almost continually to come up with the resources to maintain, not just to improve or to modernize, but to simply maintain that equipment which is already in place. It's a real struggle.

Mr. BOUCHER. Okay.

Let me, without calling on the other two panel members for answers to that question, let me move to one other question, and then I'm going to conclude in view of the length of the hearing to this point.

We talked a little bit during the first panel's presentation about the fact that this administration is evidencing something of a new direction in terms of its willingness to provide funding for what are characterized as precompetitive technologies, providing Government funding for a mission-oriented, technology developing research effort.

What are your general comments about the appropriateness of that direction and the extent to which it ought to be amplified or retarded? Again, Dr. Gjostein, let's begin with you, please.

Dr. GJOSTEIN. Well, in my oral statement I pointed out several areas where I thought it's important to orient research towards industrial competitiveness, particularly I think in the civilian industries. And I mentioned that there are particular requirements for these industries, and that is a cost driver, a high production volume driver, and to be able to do all of that, you know, with very high reliability.

It's a different set of driving forces than you have in other sectors and you have to really understand how to develop technology, you know, that meets those kind of requirements.

Mr. BOUCHER. What do you see to the argument of those who would say that the Government should not fund any kind of technology development because, inherently, that process picks winners and picks losers and that in a free market economy, that's not the role of government. I'm not suggesting that's my view, but that's, to be devil's advocate, that's what the opponents would say. How do you respond to that?

Dr. GJOSTEIN. I think there are generic, though, technologies that you can develop, that you might say are in the precompetitive arena, that can be used by a variety of industries and taken back within the company and used in a competitive sense, you know, when you add on to that your own particular innovations internally.

But there still is a need to do the generic work. For example, in the composites consortium, we have the big three combining to develop molding techniques for large composite panels, and yet we feel we can still take this technology into the company and have a competitive advantage between us.

Mr. BOUCHER. Would others care to comment on that? Dr. Acampora?

Dr. ACAMPORA. Yes, I would. I think that not only is development of some emerging technologies very, very expensive and there might not, therefore, be a need for some sort of encouragement to share some of the expense, but especially when we're dealing with generic technologies, I don't think that having Government take a lead role would necessarily be selecting winners or losers. In fact, I think we have a very good example that can be given. We have good precedent in this area, and that is the Federal Interstate Highway System.

The Federal Interstate Highway System did not select winning technologies or losing technologies. It simply provided an infrastructure that enabled the development of new technologies, new demographical shifts, some of the results being quite unforeseen. A commitment similar to that that we have for transportation might be appropriate as an example in the field of telecommunications. Do we have a national commitment to a new telecommunications infrastructure, that again would not be selecting winners or losers, but simply providing an enabling facility. I think there are some real opportunities to move forward in that direction.

Mr. BOUCHER. Okay. Dr. Weinstein?

Dr. WEINSTEIN. Yes, I would like to continue on that theme a little bit and extend it beyond just telecommunications to what I would call a national information infrastructure. It's a combination of communications and computers and media, for that matter. There needs to be some sort of master concept, I think, that Government can articulate. But what this structure might look like, I know that for the National Research and Education Network a lot of this work is being done, and I think that should be continued. And I think it will become sort of obvious who the important players are.

There will be a natural process of selection. In some cases there will be a grant selection process, just as there is now, but I think you'll see from who proposes interesting ideas, who has something to contribute, who the players are. The important thing is to articulate the vision and provide support for the infrastructure.

Mr. BOUCHER. I might add to that, that while it goes somewhat beyond the topic of this hearing, I have introduced a bill which enjoys the cosponsorship now of about 55 Members of the House, including, I'm pleased to say, the current chairman of this subcommittee, that would allow telephone companies to offer cable television service. And we specify the terms and conditions of telephone company entry.

Telephone companies have testified that, by doing that, we obtain a very rapid deployment of fiber optic cables into homes and businesses nationwide. In fact, we just about cut in half the normal schedule for that deployment. It would be 40 years without the authority to offer cable TV service; with that right, the economic incentive exists to cut that schedule down to about 20 years.

The National Research and Education Network that you mentioned is designed to basically link supercomputers, high-performance computers generally, to large research sites. I think it's going to take a generalized deployment of fiber, perhaps occurring with private sector participation through the grant of these additional incentives to get the fiber into homes and businesses and small research sites where researchers actually can get access to those supercomputers. Both steps I think are required in order to accomplish that. That, to my way of thinking, is a pretty good beginning by way of a Federal plan to have infrastructure development in telecommunications.

Do you have any suggestions for what we ought to do beyond that?

Dr. WEINSTEIN. I don't know if I should make any off-the-cuff right now, but I think that the question of access, and widespread and ubiquitous access that I was trying to emphasize, for example, in my remark about having access from libraries and schools in addition to major research institutions, is a theme to follow up on.

Mr. BOUCHER. Dr. Solberg, would you care to comment on the general subject?

Dr. SOLBERG. I had a couple of comments on the issue of precompetitive aspects. I'm a little bothered sometimes by the terms that are put on some of these. There are clearly competitive proprietary projects that belong entirely within the domain of industry, and there are clearly public interest and clearly university interest and so forth. There's a gap in the sense of the attention we have paid to

the intermediate areas, but there is not a gap in terms of the continuum of problems. So when we emphasize the extremes, we kind of lose the middle, the opportunities for collaboration. I think they tend to fall largely in this infrastructure area.

Tony mentioned the highways. The one I use in the manufacturing area a lot is the analogy to the agricultural system. If a farmer has a problem, he knows he's got a county extension agent to go to, and if the extension agent doesn't know the answer, he knows who to go to. There's a complete network to support individual farmers who are individually quite competitive. We have nothing comparable to that for manufacturing. It's because we've neglected it.

Mr. BOUCHER. Okay. I want to extend my thanks to this panel of witnesses for staying here so long with us. It's been an extraordinarily long hearing, mainly caused by the interruptions. Apologies for that.

Thank you very much for your thoughts. If you have anything additional to share with us on the range of subjects that we discussed today, the record of this hearing will remain open for a period of two weeks and we would welcome any additional submissions you care to make.

Mr. Chairman, I will yield back to you for the purpose of adjourning the hearing.

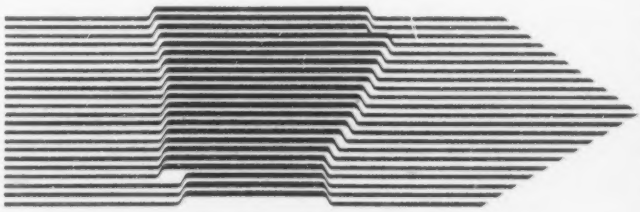
Mr. THORNTON. Thank you. And I want to thank you, Mr. Boucher, for your courtesy in allowing me to continue to sit as chairman of this subcommittee after your return, and also for scheduling this most important set of hearings, which as you said in your opening remarks has the potential of having a large impact upon our ability as a nation to enter the next century with the goals that are uppermost in our mind well served.

Thank you, and thank the members of the panel. The hearing is adjourned.

[Whereupon, at 2:03 p.m., the subcommittee adjourned.]

APPENDIX

Report on Research Funded
by the
Arkansas Science & Technology Authority
FY 1986 - FY 1990



Arkansas Science & Technology Authority
Fall 1990

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(compiled fall 1990)

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Abbreviation key:

ASU: Arkansas State University
ATU: Arkansas Tech University
OBU: Ouachita Baptist University
UAF: University of Arkansas, Fayetteville
UALR: University of Arkansas at Little Rock
UAM: University of Arkansas at Monticello
UAMS: University of Arkansas for Medical Sciences
UAPB: University of Arkansas at Pine Bluff
UCA: University of Central Arkansas

ASTA research grant programs attract non-state money

In its four years of awarding research grants, the Arkansas Science & Technology Authority has awarded almost $2.5 million in state money to 78 research projects. In return, these projects have received more than $6.2 million in follow-on and matching funding from federal, private and other non-state sources.

(Of that dollar amount $5.5 million was received in follow-on funding, an impressive figure considering many projects are relatively new and not yet expected to attract additional funding.)

This report addresses research funded by ASTA for the period FY 1986 - FY 1990 demonstrating progress towards the goal of developing and promoting Arkansas' technological resources and encouraging the use of advanced technology in the state's business and agricultural communities.

Federal contribution to Arkansas research

The level of federal funding for research and development is considered to be a significant indicator of research capacity at colleges and universities.

This report includes information showing a five-year history of federal R&D funds received by Arkansas colleges and universities with comparisons to the national average. In addition, the role of the National Science Foundation's Experimental Program to Stimulate Competitive Research in enhancing the state's capacity for research is described.

ASTA research grant programs

ASTA's Applied and Basic Research Grant Programs are designed to help the economy by improving the state's capacity for research, while seeding the growth of technology-based industry. These two programs, both of which award research grants in a competitive application process, are:

- **Applied Research Grants Program.** Applied research, to encourage development of small technology business, takes knowledge gained in basic research and investigates its use for practical and utilitarian purposes.

  Researchers applying for these grants are required to find an equal cash match from private industry. This required match is reduced to 50 percent if the company is an Arkansas firm with 50 or fewer employees.

  The applied research program has prompted investment of about $669,000 from private industry in support of research.
- **Basic Research Grants Program.** Basic research projects investigate fundamental theories and experiment to advance scientific knowledge. This type of research is the first step in bringing the benefits of science to the economic marketplace. Without basic research, applied research would have no new scientific knowledge to use in finding solutions to the problems of today and tomorrow.

  These grants provide 60 percent of the cost of the research projects with sponsoring colleges or universities providing 40 percent. The institutions' 40 percent is often paid with "in kind" services, such as researchers' salaries.

Sources of state funding for research grants

State funds used in the ASTA research grant programs come from general revenues and capital improvement funds.

In 1989 a third source of funding was made available for energy-related research projects submitted to the basic and applied grant programs. This source was a one-time grant of $300,000 from the state Petroleum Violation Escrow Fund, also known as energy funds.

Awards: FY 1986/87 - FY 1990

Research projects awarded funds by ASTA

	Fiscal Year	Number Projects Funded	ASTA Grant	Industry Sponsor Match	Follow-on Funding *
Applied Research	1986/87	7	$246,867	$246,957	$642,004
	1988	7	177,943	168,482	515,000
	1989	8	173,439	159,913	376,000
	1990	2	56,101	57,706	
	TOTAL	24	$654,350	$635,058	$1,533,004
Basic Research	1986/87	18	$621,362	N/A	$1,774,563
	1988	6	238,256	N/A	1,854,272
	1989	7	230,542	N/A	7,550
	1990	12	394,793	N/A	55,000
	TOTAL	43	$1,484,953	N/A	$3,691,375
Energy-Related Research (3 Applied and 8 Basic Projects)	1989	9	$243,672	$18,526	$230,975
	1990	2	63,470	14,637	93,827
	TOTAL	11	$307,142	$33,163	$324,802
Total		78	$2,446,445	$868,221	$5,549,181

* Follow-on funding from federal, private and other non-state sources released to date

Expenditures: FY1986/87- FY 1990

ASTA research program expenditures

Sources of follow-on funding awarded to ASTA-funded research projects

Includes federal, private and other non-state support

AGL Corp. (Jacksonville)

$6,000 for study of metal film and solar cells by Dr. Robert D. Engelken, ASU.

Alf Christianson Seed

$1,000 for development of disease-resistant spinach plants by Dr. Monroe J. Goode and Dr. Teddy E. Morelock, UAF.

Allen Canning Co. (Siloam Springs)

$164,000 for development of disease-resistant spinach plants by Dr. Monroe J. Goode and Dr. Teddy E. Morelock, UAF.

Altheimer Foundation (Altheimer)

$8,000 for development of a physiological basis for late season cotton management by Dr. Derrick Oosterhuis, UAF.

Air Force Office of Scientific Research

$242,543 for the study of magnetic resonance imaging on metabolites or drugs by Dr. Richard A. Komoroski, UAMS.

American Chemical Society Petroleum Research Fund

$18,000 for development of industrial nitro-organic synthesis by Dr. Christopher Murray, UAF.

American Society of Heating, Refrigeration and Airconditioning Engineers

$50,000 for study of heat and moisture in multi-layer walls by Dr. Rick Couvillion, UAF.

Arkansas Rice Research and Promotion Board

$16,000 to study methane from hominy waste by Dr. Terry J. Siebenmorgen, UAF.

Arkansas Water Resources Research Center

$11,600 for evaluation of acid rain's potential damage to forest-products industry by Dr. R. Scott Beasley, UAM.

Asgrow Seed

$1,000 for development of disease-resistant spinach plants by Dr. Monroe J. Goode and Dr. Teddy E. Morelock, UAF.

Bush Brothers Canning Co.

$30,000 for development of disease-resistant spinach plants by Dr. Monroe J. Goode and Dr. Teddy E. Morelock, UAF.

Embrex, Inc.

$82,000 for continued development of a new poultry vaccine by John Thoma, UAF.

Experimental Program to Stimulate Competitive Research

$7,550 for evaluation of tRNA mutants in E.coli by Dr. Scott Kirkconnell, ATU.

Gerber (Fort Smith)

$5,000 for development of disease-resistant spinach plants by Dr. Monroe J. Goode and Dr. Teddy E. Morelock, UAF.

International Business Machines

$260,000 for study of biophysical topics using nuclear magnetic resonance spectroscopy by Dr. James F. Hinton, UAF.

McCutchen Foundation

$12,000 for study of causes of complications in knee-joint injuries by Dr. Richard Webber, UAMS.

National Institutes of Health

$410,000 for study of ways to lessen soybean's allergenic qualities by Dr. A. Wesley Burks, UAMS.

$350,000 for development of industrial nitro-organic synthesis by Dr. Christopher Murray, UAF.

Continued on next page

Follow-on funding sources

$175,000 for study of causes of complications in knee-joint injuries by Dr. Richard Webber, UAMS.

$500,000 for study of biophysical topics using nuclear magnetic resonance spectroscopy by Dr. James F. Hinton, UAF.

Nuclear Regulatory Commission

$10,565 for study of potential earthquake hazard to Enola, Arkansas by Dr. Roy B. VanArsdale, UAF

National Science Foundation

$222,000 for study of biophyscial topics using nuclear magnetic resonance spectroscopy by Dr. James F. Hinton, UAF.

$117,000 for development of computer graphics and animation software to illustrate molecular motion by Dr. William G. Harter, UAF.

$44,272 for study of using aerosol technology to deposit silicon coatings by Dr. Roger M. Hawk, UALR.

$100,000 to study methane from hominy waste by Dr. Terry J. Siebenmorgen, UAF.

$87,827 for study of metal film and solar cells by Dr. Robert D. Engelken, ASU.

National Semiconductor

$500,000 for study of using aerosol technology to deposit silicon coatings by Dr. Roger M. Hawk, UALR.

Oak Ridge National Laboratory

$50,000 for study of heat and moisture in multi-layer walls by Dr. Rick Couvillion, UAF.

Pel-Freez (Rogers)

$150,000 for development of a process for large-scale production of monoclonal antibodies by Dr. Collis R. Geren, UAF.

Potash & Phosphate Institute/Foundation for Agronomic Research

$15,000 for evaluation of a growth regulator for nitrogen management of cotton by Dr. J. Scott McConnell, UAM.

Research to Prevent Blindness

$55,000 to develop an animal model to study retinopathy by Dr. John S. Penn, UAMS.

Rhone-Poulenc

$8,000 for evaluation of a growth regulator for nitrogen management of cotton by Dr. J. Scott McConnell, UAM.

Riceland Foods, Inc. (Stuttgart)

$14,975 to study methane from hominy waste by Dr. Terry J. Siebenmorgen, UAF.

U.S. Department of Agriculture

$26,910 for study of minerals affecting catfish growth & reproduction by Dr. Delbert Gatlin III, UAPB.

$30,404 for evaluation of acid rain's potential damage to forest-products industry by Dr. R. Scott Beasley, UAM.

$24,729 for development of new forest management instruments by Dr. James D. Wilson, UALR.

$249,000 development of a poultry vaccine by Dr. Craig E. Whitfill, UAF.

U.S. Department of Energy

$211,000 for study of biophyscial topics using nuclear magnetic resonance spectroscopy by Dr. James F. Hinton, UAF.

$618,000 for study of fuel economy and braking modifications by Dr. David Renfroe, UAF.

U.S. Environmental Protection Agency

$132,104 for development of a laser instrumentation of medical and industrial diagnosis by Dr. Malay Mazumder, UALR.

U.S. Geological Survey

$31,515 for study of potential earthquake hazard to Enola, Arkansas, by Dr. Roy B. VanArsdale, UAF.

University of California at Davis

$25,000 for development of a laser instrumentation of medical and industrial diagnosis by Dr. Malay Mazumder, UALR.

Wisconsin Milk Marketing Board

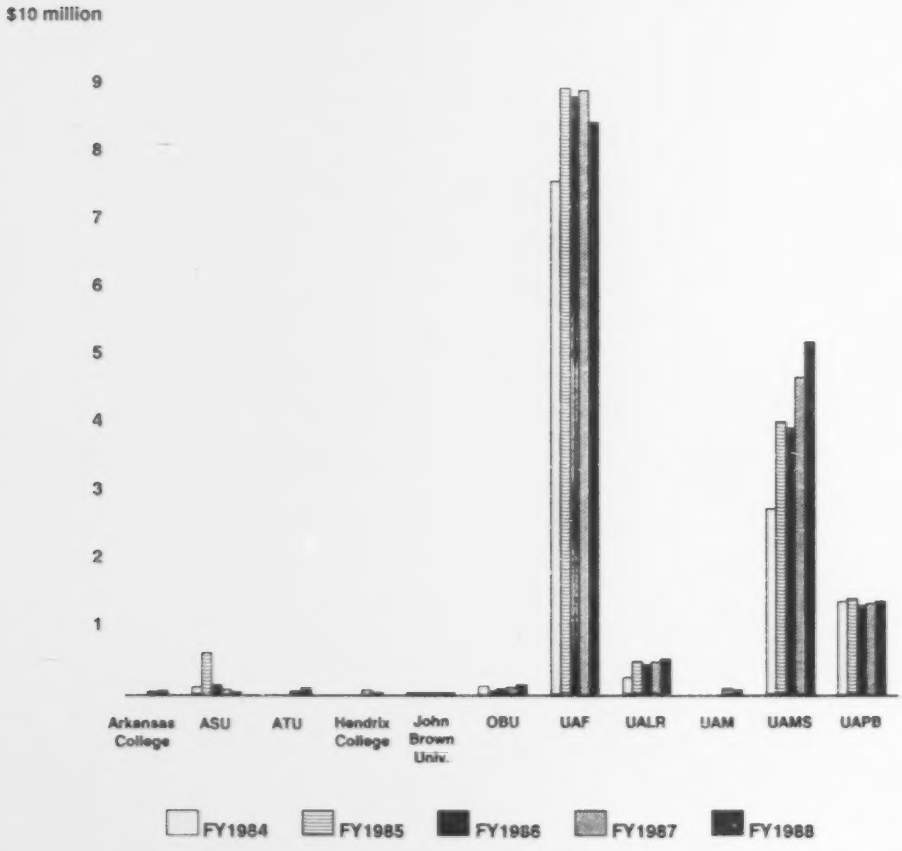
$235,000 for development of building boards from rice hulls and whey by Dr. Tito Viswanathan, UALR.

Part II:

Federal contribution to Arkansas research

Federal research & development obligations to Arkansas higher education

Funds obligated to institutions by year



Source: National Science Foundation CASPAR Database System, December 1990.

Federal R&D: FY 1984 - FY 1988

Federal research & development obligations to Arkansas higher education

University/College	Funding from federal sources (in thousands)				
	1984	1985	1986	1987	1988
Arkansas College				$8	$46
Arkansas State University	$110	$658	$176	65	28
Arkansas Tech University				25	73
Hendrix College				43	25
John Brown University	12	12	9	10	12
Ouachita Baptist University	122	18	51	82	142
University of Arkansas, Fayetteville	7,560	8,954	8,860	8,926	8,389
University of Arkansas at Little Rock	214	470	428	446	494
University of Arkansas at Monticello				48	36
University of Arkansas for Medical Sciences	2,732	3,975	3,846	4,668	5,139
University of Arkansas at Pine Bluff	1,185	1,236	1,157	1,166	1,215
TOTAL	$11,935	$15,323	$14,627	$15,487	$15,899

Source: National Science Foundation CASPAR Database System, December 1990.

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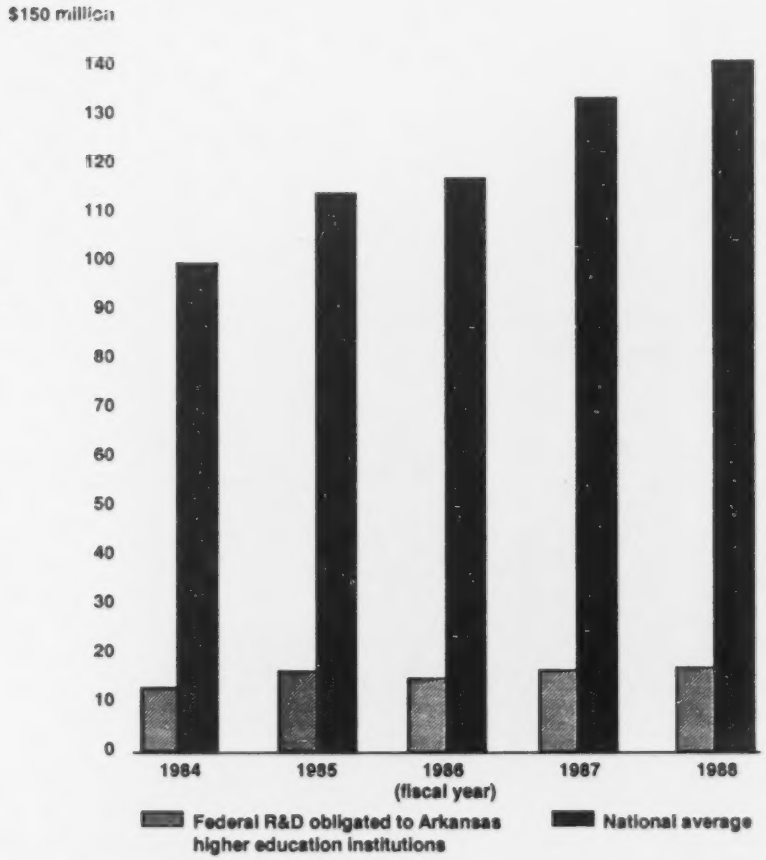
Federal obligations to higher education in Arkansas compared to national average



Sources: National Science Foundation CASPAR Database System, December 1990.
"Federal Support to Universities, Colleges, and Selected Institutions, FY 1987."

ASTA and EPSCoR help state scientists compete for federal research funding

State funding has proved to be a good method for developing Arkansas' scientific research effort, but the larger grants needed for Arkansas to become nationally competitive for federal research dollars cannot be provided by the state alone. For these large sums, the state is continuing to take advantage of a federal program, the Experimental Program to Stimulate Competitive Research.

What is EPSCoR? Established in 1979 at the National Science Foundation, EPSCoR helps support research in states such as Arkansas, which receive comparatively few research dollars from NSF and other federal agencies. The program was created at the urging of then Rep. Ray Thornton after he learned during the 1977 federal budget hearings that Arkansas received only 0.01 percent of the NSF's budget for research grant awards.

How does EPSCoR bring federal funds into Arkansas? EPSCoR, with matching grants from receiving states, provides federal funds through a competitive proposal process to help these states build up their scientific programs so they may successfully compete on a national basis for federal funds.

Through EPSCoR, a total of $4.455 million in federal funds has been awarded to help Arkansas' scientists grow so that they can increase their competitiveness for federal grants. Required state matches for these research grants totaled $5.541 million.

How has Arkansas benefited from EPSCoR? Arkansas, one of five states which received money in the first round of EPSCoR funding in 1980, was *granted $5 million in federal and state funds* over five years to support six groups of scientists and four individual scientists. Dr. Karl David Straub, director of Arkansas EPSCoR, reports that these scientists *increased their attraction of federal research money ten-fold and more than tripled their publication rate.*

The second round of EPSCoR funding in 1990 *granted $4.53 million from federal and state sources* over two years to *establish three Arkansas research clusters, called "Centers of Excellence."* The clusters are:

- Center for Protein Dynamics, headed by Roger E. Koeppe II, Ph.D., at the University of Arkansas, Fayetteville.
- Arkansas Neurobiology Center, headed by Edgar Garcia-Rill, Ph.D., at the University of Arkansas for Medical Sciences.
- Center for Cellular and Molecular Studies on Biological Aging, headed by Samuel Goldstein, Ph.D., at UAMS.

These clusters are designed to make their Arkansas scientists competitive for federal center and program/project awards. The clusters are now *working to build a "critical mass" necessary to compete nationally for these larger awards* by adding faculty, new equipment, technical personnel, and graduate and undergraduate students.

Arkansas is preparing to enter into a third round of EPSCoR funding with a request of $9 million in federal and state funds for a three year period beginning in 1992. The funding will be used to further build the research clusters established in the 1990 round and for outreach and educational programs.

EPSCoR funding in Arkansas

1979:
Planning grant for Arkansas EPSCoR program. ($125,000 federal funds)

1980-85:
1st round grants. ($3 million federal/ $2 million state)

1986:
Production of *Science Is Golden*, an Arkansas Educational Television special, and data collection. ($150,000 federal/ $150,000 state)

1989:
Planning grant. ($20,000 federal/ $21,000 state)

1990-92:
2nd round grants. ($1.16 million federal/ $3.37 million state)

1992-95*:
3rd round grants. ($4.5 million federal/ $4.5 million state)

* pending submission and acceptance of proposal in 1991.

Part III:

ASTA grants awarded FY 1986/87 to FY 1990

Applied research grants awarded

Project Description	Investigators/ University	Sponsor's Match/ Industry Sponsor	ASTA Grant	Follow-on Funding
Evaluation of causes for rice breakage during drying and storage	Dr. Terry Siebenmorgen UAF	$34,720 Riceland Foods, DICKEY-john Corp., Abbott Laboratories	$34,655	
Development of a process for large-scale production of monoclonal antibodies	Dr. Colis R. Geren UAF	$63,227 Pel-Freez, Inc	63,227	$150,000
Development of poultry vaccine	Dr. Craig E. Whitfill * UAF	$10,000 Arkansas Poultry Federation	10,000	249,000
Development of disease-resistant tomato plants	Dr. S. Jeffrey Scott UAF	$10,500 South Arkansas Fair & Marketing Association, Bradley County Chamber of Commerce	10,500	
Evaluation of acid rain's potential damage to forest-products industry	Dr. R. Scott Beasley UAM	$31,000 Weyerhaeuser Co.	31,000	42,004
Development of automated quality control inspection systems for assembly lines.	Dr. Joseph S. Wrobel UAF	$50,000 Texas Instruments, Baldwin Piano & Organ Co.	47,875	
Development of disease-resistant spinach plants	Dr. Monroe J.Goode Dr. Teddy E. Morelock UAF	$49,510 Allen Canning Co.	49,610	201,000
TOTAL for FY 1986/87		$338,857	$246,867	$642,004

* Investigator is now employed by a firm or university in another state.

FY 1988

Applied research grants awarded

Project Description	Investigators/ University	Sponsor's Match/ Industry Sponsor	ASTA Grant	Follow-on Funding
Development of instruments to allow better control of an industrial coating process	Dr. Alois J. Adams Dr. Donald C. Wold Regan Cole UALR	$11,000 Timex Corp.	$11,000	
Evaluation of a growth regulator for nitrogen management of cotton	**Dr. J. Scott McConnell UAM**	**$10,052 BASF Corp.**	**10,052**	**$23,000**
Development of high-quality gun shot	Dr. William Schmidt Marcus Langston Dr. Harold Shreshta Dr. Thomas Landers UAF	$46,368 Daisy Manufacturing	35,466	
Development of additional disease-resistant spinach varieties	**Dr. Monroe J. Goode Dr. Teddy E. Morelock UAF**	**$49,610 Allen Canning Co.**	**49,610**	
Study of ways to lessen the soybean's allergenic qualities	Dr. A. Wesley Burks Dr. Larry W. Williams Dr. Helen L. Butler Dr. Stephen Fiedorek UAMS	$23,075 Ross Laboratories	23,075	410,000
Development of laboratory methods for the industrial production of nitro-organic compounds	**Dr. Neil T. Allison Dr. Norbert J. Pienta * UAF**	**$20,377 Garrison Industries**	**40,740**	
Continued development of new poultry vaccine	Dr. Craig E. Whitfill * John Thoma Nicolas Roy Giles John K. Skeeles UAF	$8,000 Arkansas Poultry Federation	8,000	82,000
TOTAL for FY 1988		**$168,482**	**$177,943**	**$515,000**

* Investigator is now employed by a firm or university in another state.

Applied research grants awarded

Project Description	Investigators/ University	Sponsor's Match/ Industry Sponsor	ASTA Grant	Follow-on Funding
Development of a low-cost laser beam detector	Dr. Robert D. Engelken Dr. Hal McCloud ASU	$25,473 AGL Corp.	$25,473	
Robot therapy for spasticity	Dr. Stevenson Flanigan UAMS	$40,000 Isokinetics, Inc.	35,417	
Feather meal feed for wintering beef cows	Dr. Arthur L. Goetsch UAF	$7,000 Cargill, Pilgrim's Pride, River Valley By-Products	7,000	
Isolation of fertilization bio-chemicals for poultry breeding	Dr. Grover C. Harris UAF	$8,000 Arkansas Poultry Federation	8,000	
Development of industrial nitro-organic synthesis	Dr. Neil T. Allison Dr. Christopher Murray UAF	$18,108 Garrison Industries	36,217	$368,000
Development of a physiological basis for late season cotton management	Dr. Derrick Oosterhuis UAF	$20,082 Alzheimer Foundation	20,082	8,000
Advancement of the E-SPART analyzer	Dr. Malay K. Mazumder UALR	$30,000 AGL Corp.	30,000	
Expert check and cash teller system	Dr. John Talbutt UALR	$11,350 Arkansas Systems	11,350	
TOTAL for FY 1989		$159,913	$173,439	$376,000

FY 1990

Applied research grants awarded

Project Description	Investigators/ University	Sponsor's Match/ Industry Sponsor	ASTA Grant	Follow-on Funding
Beef cattle resistance to arthropods	Dr. C. Dayton Steelman Dr. A. Hayden Brown UAF	$28,525 Granada Genetics, Inc.	$26,920	
Allergenicity of rice proteins	Dr. A. Wesley Burks UAMS	$29,181 Rosa Laboratories	29,181	
TOTAL for FY 1990		$57,706	$56,101	$0

Basic research grants awarded

Project Description	Investigators/ University	ASTA Grant	Follow-on Funding
Development of genetic control of catfish growth & reproduction	Dr. Ernest Peck Jr. * Dr.James W. Hardin UAMS	$53,200	
Study of minerals affecting catfish nutrition	Dr. Delbert Gatlin III * UAPB	16,242	$886,297
Study of stream resource management techniques	Dr. Arthur V. Brown UAF	44,075	
Study of parasite transmission in bait fish	Dr. Stanley E. Trauth ASU	18,971	
Development of new forest management instruments	Dr. James D. Wilson UALR	24,695	24,729
Development of building boards from rice hulls and whey resins	Dr. Tito Viswanathan UALR	51,250	236,000
Development of herbicide-resistant bermuda grass	Dr. John W. King Dr. Feng H. Huang UAF	30,010	
Development of laser instrumentation of medical and industrial diagnosis	Dr. Malay K. Mazumder UALR	50,003	157,104
Development of new laser material	Dr. Larry D. Merkle * UAF	47,500	
Development of process for making chemical compounds with lasers	Dr. David L. Morse * UAF	14,999	
Development of new chemical solvents	Dr. Norbert J. Pienta * UAF	24,615	
Continued on next page			

* Investigator is now employed by a firm or university in another state.

FY 1986/87

Basic research grants awarded (continued)

Project Description	Investigators/ University	ASTA Grant	Follow-on Funding
Study of friction characteristics of a new brake design	Dr. David A. Renfroe UAF	$77,816	
Application of robotics in factory automation	Dr. Engin Yaz UAF	25,181	
Study of causes of complications in knee-joint injuries	Dr. Richard Webber UAMS	51,330	$187,800
Development of instrument for early diagnosis of congenital hip disease	Dr. Paul C. McLeod Jr. UALR	16,221	
Study of magnetic resonance imaging of metabolites or drugs	Dr. Richard A. Komoroski UAMS	42,442	242,543
Study of potential earthquake hazard to Ozarks, Arkansas	Dr. Roy B. VanArsdale UAF	16,646	42,000
Development of mathematical approach to modeling complex systems	Dr. Zdzislaw Jackiewicz UAF	16,267	
TOTAL for FY 1986/87		$401,082	$1,774,553

Basic research grants awarded

Project Description	Investigators/ University	ASTA Grant	Follow-on Funding
Study of biophysical topics using nuclear magnetic resonance spectroscopy	Dr. James F. Hinton UAF	$94,500	$1,193,000
Development of catfish with supergrowth and special spawning characteristics	Dr. Ernest Peck Jr. * Dr. James W. Hardin UAMS	36,870	
Development of computer graphics and animation software to illustrate molecular motion	Dr. William G. Harter UAF	8,950	117,000
Use of cactus moth to control prickly pear infestations in North Central Arkansas pasturelands	Dr. Chris E. Carlton Dr. Timothy J. Kring UAF	13,696	
Use of aerosol technology to deposit silicon coatings	Dr. Roger M. Hawk Dr. Robert Bond Kamesh Gadepally UALR	49,903	544,272
Use of laser technology to study the motion on nonspherical aerosol particles in fluids	Dr. Darrell Keith Hutchins Doug Wilson UALR	34,438	
TOTAL for FY 1988		$238,256	$1,854,272

* Investigator is now employed by a firm or university in another state.

FY 1989

Basic research grants awarded

Project Description	Investigator/ University	ASTA Grant	Matching Funding
Photothermal spectroscopies in media	Dr. Rajendra Gupta UAF	$77,370	
Collisional quenching of metastable oxygen	Dr. Richard Anderson * UAF	[illegible]	
Evaluation of tRNA mutants in E.coli	Dr. Scott Kirkconnell ATU	22,500	$7,550
Mineralogy of the Granite Mountain Syenite	Dr. Harry L. Ransood * ATU	[illegible]	
Synthesis of isogenic alloplasmic cotton lines	Dr. James McD. Stewart UAF	29,650	
NMR coils for in-vivo imaging and spectroscopy	Dr. Roger M. Hedt UALR	[illegible]	
Synthesis of thienylamphetamine derivatives	Dr. Dominic R. Yang UALR	31,497	
TOTAL for FY 1989		[illegible]	[illegible]

* Investigator is now employed by a firm or university in another state.

Basic research grants awarded

Project Description	Investigators/ University	ASTA Grant	Follow-on Funding
Study of vector controlled alternating current drives	Dr. Juan C. Balda UAF	$54,305	
Determination of cimetidine in capillary zone electrophoresis	Dr. Arthur Hoyt, Jr. UCA	10,846	
Establishment of a molecular structure determination facility	Dr. A. Wallace Cordes UAF	12,559	
Molecular modeling of biomacromolecules	Dr. Cesar M. Compadre UAMS	29,197	
Application of rare earth electrodes in PCB destruction	Dr. Roger M. Hawk UALR	24,813	
Development of refractometer from soybean oil hydrogenation	Dr. Alois J. Adams Dr. Robert A. Sims UALR	25,958	
Development of fluidized gas air filtration	Dr. Malay K. Mazumder UALR	25,902	
Investigation of doped PECVD SIPOS films	Dr. Simon S. Ang UAF	42,632	
Development of an animal model to study retinopathy	Dr. John S. Penn UAMS	40,000	$55,000
Investigation of quantum statistics of non-classical states	Dr. Reeta Vyas UAF	39,794	
Exploration of user interface management system for computer-based instruments	Dr. Gary A. Anderson UALR	37,425	
Effect of dietary pectin on serum cholesterol in diabetics	Dr. Komalam Jairaj UAPB	42,302	
TOTAL for FY 1990		**$394,793**	**$55,000**

FY 1989

Energy-related research grants awarded

Project Description	Investigators/ University	Sponsor's Match/ Industry Sponsor	AETA Grant	Follow-on Funding
Geologic model of the Batson gas field	Dr. Roy B. VanArsdale UAF	N/A	$59,200	
High temperature superconductors	Dr. Thomas J. Turner OSU	N/A	34,917	
Calibration of the Gamma Ray and Neutrino Detector (GRANDE)	Dr. Alois J. Adams Dr. Robert Bond UALR	N/A	22,744	
Methane from hominy waste	Dr. Terry J. Siebenmorgen UAF	N/A	5,000	$130,975
Indoor air-quality control	Dr. Malay K. Mazumder UALR	N/A	38,487	
Heat and moisture in multi-layer walls	Dr. Rick Couvillion UAF	N/A	43,780	100,000
Atomic hydrogen detection by MRI	Dr. Rajendra Gupta UAF	N/A	15,392	
NMR imaging of core floods	Dr. Richard A. Hazlewood UAMS	$12,500 ARCO Oil & Gas	12,500	
Energy-efficient refrigerator design	Dr. Burton Henderson UALR	$6,026 American Dixie, Inc.	11,652	
TOTAL FY 1989		$18,526	$343,672	$230,975

Energy-related research grants awarded

Project Description	Investigator/ University	Sponsor's Match/ Industry Sponsor	ASTA Grant	Follow-on Funding
Automated building controls	Dr. Sandra C. Parker UAF	$14,637 Energy Techniques	$27,342	
Metal film/solar cells	Dr. Robert D. Engelken ASU	N/A	36,128	$93,827
TOTAL for FY 1990		$14,637	$63,470	$93,827

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After five years, the SILO program has become assimilated into the legislative infrastructure and is beginning to play an important role in policy decisions at every level. During the next five years, it can be expected to increase its influence as more and more highly sophisticated and technical matters come before the General Assembly

From, SILO: The First Five Years
June 15, 1984

State legislators, who for the past decade have prided themselves on their ability to provide innovative solutions to problems once handled at the federal level, are beginning to chafe under the weight of their new burdens.

The Washington Post
April 30, 1990

EXECUTIVE SUMMARY

•As the SILO program enters its second decade of service to the General Assembly and citizens of the State of Arkansas, it can look back with a tremendous sense of accomplishment to the successes of its first decade.

•The Legislative Joint Performance Review Committee, the Bureau of Legislative Research, and the Arkansas General Assembly have worked jointly to create a vehicle for presenting complex policy issues in a timely and professional manner to a lay audience of legislators and state officials.

•The task for SILO, during its second decade, will be to enhance the services it provides to the Arkansas General Assembly

-by further developing the work of its Advisory Council

-by involving its Advisory Council more directly in the formulation and exposition of issues likely to surface during the decade

-by developing a closer working relationship between SILO staff and the Advisory Council in the execution of research studies and written reports

and

-by creating a formal vehicle for monitoring federal issues and initiatives which are likely to have a major future impact on Arkansas.

THE ARKANSAS LEGISLATIVE PROJECT AND SILO PROGRAM 1984 - 1989

The Science Information Liaison Office of the Arkansas General Assembly has been in operation for ten years. This anniversary represents something of a victory for those who conceived and organized the original project, maintained their loyalty to the program when federal funds were withdrawn as a result of Reagan Administration budget cuts, and who retain their interest in the institution as it enters its second decade of service to the state's General Assembly and academic/scientific community.

SILO, or the Arkansas Legislative Project, as it was originally called, was conceived as a means of linking the state's vast scientific and technical resources - largely housed in its institutions of higher education - with the growing technical information and data needs of the General Assembly.

The concept was simple. By the late 1970s, the state's part time citizen legislators were faced with the need to become full time experts, as sophisticated issues such as water and air pollution, ecology, hazardous waste, and space age technology began to crop up with alarming frequency. The resources to educate the legislators were available. But it was not always easy to translate - or link - what the legislators needed with what the scientific community had at hand. The SILO program would provide the link: by handling inquiries for technological and scientific information, by sponsoring conferences and meetings to discuss and evaluate current scientific and technological issues, and by assisting the

scientific and technological community to present its needs before the General Assembly.

The SILO program was originally financed with a $166,000 grant from the National Science Foundation in 1979. Although it was one of many similar grants approved by the NSF's State Science, Engineering and Technology Program, it was the first project to be staffed by an academic institution under the jurisdiction of a legislative committee. The academic institution was the Center for Urban and Governmental Affairs at the University of Arkansas at Little Rock; and the legislative committee was the General Assembly's Joint Performance Review Committee.

During its initial five years of operations, the SILO program achieved a notable record of success:

• SILO became an essential element in the Arkansas legislative process by providing useful technological and scientific information, analysis, and recommendations on a variety of issues coming before the General Assembly, including hazardous waste, rabies, water and air pollution, effect of overweight trucks on road surfaces, requirements for establishment of a high tech academic institution, and many other topics.

• SILO brought together members of the General Assembly and the state's academic and scientific community in a series of conferences designed to increase legislative awareness of new scientific and technological issues. The conferences were also designed to acquaint academics and scientists with the information needs of the General Assembly on specific issues.

•The SILO program survived a Reagan Administration budget reduction effort which eliminated federal funding for NSF state scientific

support programs. Funding was continued through the joint efforts of the General Assembly and the University of Arkansas.

•The Legislative Chairman of the SILO program was named chairman of the National Council of State Legislature's Committee on Science and Technology.

•The first director of the SILO program - UALR Professor Phyllis Garnett - was named director of the state's Department of Pollution Control and Ecology.

•The SILO office in the State Capitol became the principal vehicle for handling legislative analysis and referral of scientific and technological matters.

During the SILO program's second five years, the office expanded and refined its services to the state's legislative community and the Office of Legislative Research of the General Assembly.

The establishment of a SILO Advisory Council during this second five years has been a vital ingredient in the continued health of the organization. Currently, the SILO Advisory Council is composed of 18 members representing the areas of science, elementary and secondary education higher education, business, community service and the legislature. The membership includes the co-chairmen of the Legislative Joint Performance Review Committee (JPR) and the SILO Director.

Members are appointed by the director with approval of the executive committee, which includes the JPR co-chairmen and the Advisory Council chairman. Each member serves a three-year term and appointments are staggered so that each year only five terms expire. The chairman is selected by the membership and cannot be a legislative member or the SILO director.

The current executive committee members are Chairman Charles Dunn, Senator Nick Wilson and Representative John M. Lipton. Cathy Feild is SILO director.

Council meetings are called by the chairman and are staffed by the SILO office.

The Advisory Council formalized its role in the SILO Program in the following October, 1988, directive:

"The SILO Advisory Council was created in June 1984 to replace the SILO Editorial Board, which had served as advisor of the SILO newsletter. SILO is a joint project of the Legislative Joint Performance Review Committee of the Arkansas General Assembly and the University of Arkansas at Little Rock. Because of SILO's unusual structure as a liaison between the higher education community and the General Assembly, the Council is in a unique position to assist the legislature on complex issues.

The Advisory Council performs a dual mission. First, it provides a part-time legislature with objective information, research and analysis on present or future issues of state-wide importance. Along these lines, SILO also seeks to keep legislators informed on various scientific issues, a task stemming from SILO's origin as a grant program of the National Science Foundation. Secondly, it can reassess issues already addressed by the legislature.

Through research, newsletters, issue briefs and conferences, the SILO Advisory Council is able to assist state legislators with the decision-making process by communicating information on a broad range of important topics. In addition, these same resources can be utilized to assist and inform scientists, educators, business leaders, community service organizations and others."

• • • • •

This report will deal primarily with the activities and issues confronting the SILO program during the next five to ten years.

There is little doubt that the consolidation of the SILO program into the life of the Arkansas General Assembly and the state's institutions of higher education has been intensified during the past five years. To say that a program has become an 'institution' is, in this case, a compliment. Most of the state programs funded by the NSF have been abandoned. The Arkansas program continues to be successful - largely because of a continued commitment by all parties on the need for good, easy-to-understand information and analysis of highly technical problems and issues.

During its second decade, SILO will have to confront the increasingly complex issues of the last decade of the 20th century.....natural resource management and conservation, acid rain, telecommunications and information technology, robotics, epidemiology, and problems in meeting the laudable but costly goals set recently by the nation's governors in the field of elementary and secondary education and, perhaps most important, the need to provide a continuing level of services and benefits in an era of dwindling revenues.

The challenge to SILO in the next decade is three-fold:

- To choose among the seemingly countless issues those which will have the greatest impact on the State of Arkansas
- To bring together adequate scientific and technical resources to master the increasingly sophisticated nature of those issues

and

- To interpret those issues effectively to elected officials who must resolve those issues.

This is no simple task. To insure success, the program will require the continued commitment of those who supervised its growth during its initial decade and the continued good will of the state's scientific and technological community which must provide the information and sophisticated analytical skills to make it work. The key ingredient, however, is the continued commitment of the SILO Advisory Council to the need for improved resources to deal with the complex issues which face Arkansas and its General Assembly in the coming decade.

MEETING THE CURRENT AND FUTURE NEEDS OF THE LEGISLATIVE AND SCIENTIFIC COMMUNITY

Today's legislator is basically a 'crisis manager'. He concerns himself almost exclusively with proposals for resolving current issues. The Arkansas General Assembly has an excellent resource for dealing with these issues in its Bureau of Legislative Research, a highly professional research and analytical arm of the legislature. During the period when the General Assembly is not in session, the Bureau of Legislative Research functions as a vehicle for studying issues which are likely to surface as specific legislative proposals during the next session. It also provides assistance to the General Assembly in analyzing specific budgetary proposals for action during the next session. The Bureau of Legislative Audit and the Legislative Audit Committee of the General Assembly oversee funds already appropriated for state agencies.

The SILO office, its advisory committee, and the House and Senate members of the Legislative Joint Performance Review Committee have undertaken the task of stimulating creative discussion on long range issues and broad policy topics not necessarily contained in specific legislative proposals and have also responded to specific requests for assistance in dealing with issues beyond the capacity of the regular research facilities of the Bureau of Legislative Research. Its quarterly newsletter has provided legislators and other interested parties a regular means of keeping up-to-date on these issues. Unlike the legislative 'crisis managers' who must assimilate a great deal of information quickly and arrive at a solution to a pressing current problem, the SILO program generally deals with broader,

more complex issues which - although equally critical - lend themselves to more contemplative study.

The Arkansas SILO program has, in the past, played a significant role in targeting major issues of concern to the Arkansas General Assembly and providing a forum for educating legislators and state officials to work out options and solutions for dealing with these issues. The major focus of the SILO program has been threefold:

- Conferences bringing together state officials, legislators, members of the academic community, and outside experts to discuss, informally, selected issues of significant impact on the State of Arkansas and provide a forum to relay information on these issues to interested parties and the public at large.
- Newsletters, issue briefs, and other reports bringing to a larger community the most important issues facing the state and a range of options for legislative and executive action.
- Specific assistance to members of the Arkansas General Assembly and its committees on a wide range of topics under consideration by the legislature.

Because the SILO program is no longer funded by the National Science Foundation, it has been able to expand the list of topics under consideration to include a wider range of non-scientific and non-technical issues. It has also been able to streamline its method of access to the state's academic community by dealing directly with experts on university campuses, thereby providing more efficient and timely information to its legislative client base. Most important, perhaps, has been the development of a committed and energetic SILO Advisory Council, which can put its own

scientific, technological, and intellectual resources directly at the disposal of the General Assembly. There is no doubt that these developments have contributed to the continued success of the program.

At the same time, it has become increasingly evident to those associated with the SILO program that the next few years will require an extensive change in the way SILO meets its commitment to the expanding needs of the Arkansas General Assembly and state officials. The required change comes directly as a result of the increasing number of complex issues looming on the not-too-distant horizon, the need to develop helpful and creative solutions, and the challenge to react quickly as unforeseen problems arise.

The task, then, for SILO, as it enters its second decade, is to

- **mobilize existing resources**
- **develop new resources**
- **create a mechanism for anticipating (or reacting quickly to) unforeseen problems as they arise.**

This will require not only a more active role for the SILO Advisory Council, but also a change in the way it functions, both as a committee and as a vehicle for constructive and creative assistance to the General Assembly.

All this represents not only a challenge for the SILO program, but also an opportunity to put Arkansas in the lead as a state which mobilizes a variety of resources to provide non-partisan and non-biased direction and solutions to lawmakers. The SILO program can serve as a model for other states which have not yet dealt with the need to create mechanisms for highly professional assistance in analyzing major complex issues. It can also point the way to areas where states can enhance their competence in

handling complex issues internally without the need to commit extensive financial resources to outside consultants.

THE ISSUES

In some respects, it is almost academic to discuss 'issues' and their impact on Arkansas in the 1990s. Most of the problems are clear: lack of money, need to commit more money to education, the environment, health care, care of the elderly, water and sewage improvements, better highways, taxation and poverty. There is also the likelihood of unforeseen issues becoming of paramount concern during the upcoming decade. No one yet knows, for example, the extent of the damage caused by the failure of so many savings and loan institutions on the long range prospects of southwestern states like Arkansas and how this issue will impact on related areas like industrial growth, housing, and property tax revenues.

Perhaps the biggest issue facing the states in the next decade is the effect of a slowdown in the economy on already tight state revenues. The struggle to balance what one commentator has called the "growing demands on government against dogged public resistance to higher taxes". Faced with a sluggish economy that is eroding state revenues and putting increased pressure on state budgets, the states can do little to meet the increasing demands of school age children and the elderly. All this is likely to produce a serious clash of interests during the next few years. And the response may very well consist of a combination of unpalatable solutions: termination of programs, higher taxes, and reduced services.

At this point, there are few answers to the growing number of issues which will dog Arkansas and its legislature during the decade. A brief review of some of these issues, however, and their likely impact on Arkansas is instructive in helping the SILO program to focus on areas

where it must put its resources to work in providing options for legislative action.

• The Peace Dividend and Its Impact on the States

The major issue facing the State of Arkansas - and its 49 fellow state governments - during the 1990s will, of course, be money. In some respects, this issue is out of the hands of the states. The cause and the solution to the states' financial crisis will be in the hands of the Federal Government. The ever-looming Federal deficit, the dictates of the Graham-Rudman deficit reduction legislation, the massive costs associated with the need to bail out the nation's failing savings and loan institutions, and the Bush Administration's continued reluctance to discuss new taxes will have an obvious impact on the way states allocate available resources. The prospect of a massive shift in program and fiscal responsibility away from the federal government onto the shoulders of the states will also influence developments in the various states. National concerns such as the need to put more emphasis on the environment, meet the needs of the rapidly increasing numbers of older Americans, and deal with the increasingly vocal demands of the poor, the homeless, and disadvantaged minorities, will all end up putting greater strains on state governments.

One vitally important, but difficult to measure, development of the 1990s will be the so-called "Peace Dividend" resulting from an unanticipated relaxation of tensions between the United States and the Soviet Union. The likelihood that there will be a significant cutback in defense spending by the Federal Government promises both advantages and disadvantages for states like Arkansas. The cutback - estimated at up to $150 billion per year - could mean a significant cutback in military

installations and personnel, as well as in goods and services. Arkansas could feel this impact directly, both in terms of army and air force installations located in the state, and in defense contracts to Arkansas firms.

On the plus side, there is the prospect that the additional $150 billion per year would be used to make badly needed investments in America's environment and badly abused infrastructure.

As soon as it became apparent that a gradually scaled down defense budget would provide a financial bonanza, the halls of Congress became crowded with interest groups eager to cash in. As **The New York Times** recently put it: "already the line of people with worthy claims stretches around the block".

Some have suggested spending the defense funds on strengthening Eastern Europe. Others have urged a badly needed increase in spending on social welfare programs. Still others have urged that the dividend be used to reduce the federal budget.

At this point, the peace dividend is still the proverbial pie in the sky. International developments, such as a worsening situation in Lithuania and other Soviet Republics, could cancel the dividend. But, if it does come to pass, there is growing talk in Washington that the dividend should be used to focus on the environment, education, health, and the restoration of the nation's crumbling infrastructure - transportation, highways, water, sewerage, sanitation, and recreational resources. If this comes to pass, the impact on states like Arkansas could be dramatic. Not only would the increased spending on critical areas like education, health, and infrastructure provide badly needed relief for the states, but it would also

help to ease the impact on states caused by closing of military bases and fewer defense contracts.

•Shifting the Financial Burden To The States; the Bush Administration Proposals.

Until the peace dividend issue is thrashed out at the national level, one of the major initiatives of the Bush Administration is to shift more of the funding for state-aid programs to the states themselves.

In March, for example, the Administration announced a new transportation policy which would put more of the burden for highway construction and repair, airport improvements, and other transportation needs on the states. The new policy, which would place emphasis on repairing the Interstate Highway System, end congestion at airports, extend hazardous material regulations to intrastate shipments, and earmark funds for badly needed mass transit and railroad improvements, would also end federal assistance in many areas. States would be asked to pay a greater share of federal-aid highway projects. The Bush proposal would also reduce federal operating assistance to urban mass transit systems, end federal funding for AMTRAK, and recover a higher percentage of airport improvement costs from users and state funds.

The new transportation policy has been roundly criticized by state officials. According to New York Governor Mario Cuomo:

"This plan perpetuates the existing Federal fiscal policies that continually seek to force state and local governments to pick up the slack for proposed Federal cutbacks in domestic programs."

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It seems clear that, barring a massive influx of funds to the states as the result of cutbacks in defense spending, the states will be forced to take up the burden once carried by the federal government. This will require, not only a creative effort to come up with additional revenues, but also a massive creative effort to deal with issues which were once the exclusive responsibility of the federal government.

•Education: The National Governors' Association Goals for The Year 2000

Education will continue to force the states to enter uncharted waters in the 1990s. The impressive education goals enunciated by the National Governors' Association for the year 2000 will require states like Arkansas to invest considerable resources to develop creative and workable programs to meet these goals. The requirement to meet these goals places an especially heavy burden on Arkansas simply because the author of the NGA report is the Governor of Arkansas. The SILO Advisory Committee must list as its highest priority the task of assisting the General Assembly to come up with the programs to meet goals set for combatting high school dropout rates, illiteracy, and low test scores by the NGA.

On a more general level, it is apparent that the state's system of elementary, secondary, and higher education will require the full commitment of the General Assembly during the 1990s. Recent events, such as the approval of increased millage rates to support the state's largest school district in Little Rock, show promise of an increased commitment on the part of the state's citizens to the state's education needs. It is also apparent that there will be renewed efforts to resurrect the Head Start program and other enrichment programs for disadvantaged

Arkansans. Whether these programs will take the same shape as earlier efforts is not yet clear. What is clear is that SILO can take the lead in shaping creative discussion and debate on the future education needs of the state. Its past efforts - in the form of conferences, reports, and specific assistance to the General Assembly during its recent special session on education - give it a leadership position in this area. Its unique position and Advisory Council resources place it in an excellent position to assist the General Assembly and state officials to meet the challenge.

• The Savings and Loan Bailout And Its Impact On Arkansas

The cost of bailing out the nation's failing savings and loan industry is impossible to estimate at this time. Some claim that the entire peace dividend will be spent on the savings and loan bailout. Whatever the cost, the impact is bound to be great - on the nation as a whole and on Arkansas in particular. While the issue itself is largely out of the hands of state officials, its indirect impact will play a large role on the state. There is no doubt that it has had and will continue to have a major influence on new housing, mortgage availability, employment, and revenues derived from property taxes. This will have an effect on programs which are dependent on a healthy economic climate and the revenues derived from the property tax. Since many federally supported programs are also dependant on the availability of revenues, the resources devoted to the bailout will make funding for such programs in extremely short supply.

The Arkansas General Assembly, already faced with the problem of inadequate funding and a growing list of competing demands on state and local revenues, will undoubtedly have to face the issue as early as its next session. Here, too, the SILO program can assist by providing the General

Assembly with good data on the likely impact of the bailout and its effect on state programs.

•New Federal Regulations on Environmental Quality

Environmental issues will continue to play an important role in the deliberations of the Arkansas General Assembly. New regulations recently issued by the federal Environmental Protection Agency - particularly those regulating landfills - will have a direct impact on Arkansas. Most existing landfills in Arkansas will become obsolete under the new standards, requiring costly replacement programs in order to bring existing landfills into compliance or replace obsolete facilities. Water quality standards and proposed emission quality standards will also become priority issues for the state during the decade. Legislation currently before the U.S. Congress dealing with air and water quality is likely to produce costly new regulations on Arkansas industry and utilities and could have an impact, not only on utility rates, but also on peripheral areas such as taxes and regulatory requirements imposed on the states by the federal government.

Related environmental issues, such as wetlands preservation and their vital role in the preservation of existing water quality - as well as the issue of disappearing wetlands - are important conservation issues facing the state during the decade.

•Decaying Infrastructure

Many states have delayed making costly improvements to or replacements to decaying, obsolete, or inadequate infrastructure. This includes not only urban and renewal highway systems, already outlined, but also water and sewer lines, public facilities, recreational facilities, and

plant maintenance. In many larger American cities, the problem of crumbling infrastructure has reached a crisis level. And the longer the needed improvements are delayed, the costlier they will become. The Federal Transportation Department estimates, for example, that motorists in urban areas now experience two billion hours a year in highway delays. Flight delays at 21 major American airports now amount to 20,000 hours a year. While this is not yet a major problem at Arkansas airports or on Arkansas highways, it is evident to anyone traveling outside the state by car or by air. And the congestion - particularly from heavy truck traffic - on the state's interstate highways is becoming particularly acute.

Delayed maintenance of state facilities - particularly noticeable to anyone associated with the state's institutions of higher learning - is somewhat understandable in light of competing priorities. But delays are, in the end, costly. And, sooner or later, they must be dealt with. Arkansas has also not dealt with the need for additional correctional facilities and the need to improve existing facilities. The state's prison population is experiencing the same healthy increase as in many other states. Newly imposed mandatory prison sentences for certain offenses, an increase in drug and alcohol-related offenses, and growing recidivism require not only an increase in programs to combat the root causes of the problem, but also in facilities to handle the increased number of prison inmates.

These are but a few examples of 'crumbling infrastructure' which must be dealt with by the State of Arkansas during the decade.

•Poverty

Poverty, urban and rural, continues to plague Arkansas. The state's Delta Region has recently become the focus of increased attention and is

benefitting from public efforts such as the recently formed multi-state commission, as well as private foundation efforts. There is likely to be increased pressure during the next few years to make substantial progress in dealing with this issue. This is likely to surface in legislative proposals and new financial initiatives to meet the problem. Because so much of what is proposed ends up having little or no impact on the root causes of the problem, it is important the General Assembly have the benefit of good analysis of issues and programs likely to develop during the decade. A good example of such efforts is the program recently enacted in the State of Mississippi to combat functional illiteracy, both in the school-age and adult population. The SILO program could be an important link between the General Assembly and groups which are working to combat problems associated with poverty.

• The Elderly

The issues facing the state's growing elderly population encompass those involving many younger Arkansans - poverty, health, taxation, housing, and related issues. New federal regulations governing nursing homes and long-term care; cutbacks in Medicare; increasing property taxes; increased demands on state services and public institutions and facilities; the need to provide better financial counseling for the elderly; and even the problem of illiteracy - all promise to become important issues in the decade. The General Assembly will be required to deal with these issues and will need impartial, expert assistance in anticipating the impact of these issues on state revenues and services.

•Prison Overcrowding

New laws and stiffer sentences - as well as court orders to ease overcrowding - are placing intolerable burdens on the states' prison systems. Last year, the nation's state prisons held 644,000 inmates, up 67,000 over the previous year. Federal prisons held 56,500 inmates, and increase of 12,000 over the previous year. Some 37 states are now under federal court order to improve prison overcrowding. But, despite $8.4 billion in new prison facilities authorized during the past two years, the situation only gets worse. The dramatic increase in prison inmates results from a large number of drug related crimes, a decline in paroles, and tough new criminal laws which require longer prison sentences for many classes of felonies.

SILO's ROLE

Many of the issues facing Arkansas are unique to the state. Others are larger, federal issues which have an impact on the state. And several issues are international in scope and filter down to Arkansas in the form of federal budgetary decisions taken as the result of United States foreign policy initiatives. The current Administration in Washington is also undertaking several policy changes which will force the states to accept an even greater share of support for programs which were once the gift of the Federal Government. And huge, costly mistakes in the private sector will also have a serious impact on the state as it continues to face the shock waves of massive financial failure in the savings and loan industry.

More than ever, Arkansas needs programs like SILO to give the state an edge in meeting these challenges - so that it does not have to react at a crisis level when the full impact is already felt.

SILO has already proven its value to the General Assembly. The fact that the program is still in existence after ten years is proof enough of its staying power. The challenge for the next decade will be to translate that staying power into a powerful force for meeting future needs of the General Assembly.

The SILO program has four critical needs as it enters its second decade of service:

•To establish specific goals and objectives so that it can operate efficiently and measure progress

•To transform the SILO Advisory Council from a consultative body into a decision-making task force charged with specific responsibilities for meeting the program's objectives

•To enlarge the Council's membership to provide additional advisory support for the Council's new duties.

•To devise a mechanism for integrating individual legislators and the staff of the Legislative Research Bureau into the SILO program

•To establish a formal liaison with the state's Congressional delegation in order to provide the General Assembly and other state officials with timely information on anticipated federal actions likely to have an impact on the State of Arkansas. Since the majority of issues facing Arkansas in the current decade result from federal initiatives, it is vital to have a formal structure to provide that information.

During the past ten years, the SILO program has changed significantly in scope and activities - from an initial period in which it fulfilled the requirements of its National Science Foundation grant to serve as a link between the state's scientific and technological resources and operate as an 'intake' office for data and research on various scientific/technological issues - to a program which, in effect, initiates studies and research on current issues and provides important consultative services based largely on internal staff research. It has also changed from a program for providing scientific and technological research into a more generalized research unit providing studies on a variety of non technical issues. In making the transformation, it has worked closely within the existing research facilities of the Bureau of Legislative Research and

complements rather than duplicates the work done by that office. It is an established component of the legislative process in Arkansas and has been able to overcome initial doubts over its ability to insinuate itself into the regular legislative processes. The fact that it now receives official referrals from legislative committees, as well as numerous requests from individual legislators, is an indication of its acceptance by the General Assembly.

Having established itself and having continued its successful series of legislative conferences and seminars, the SILO program has also initiated a successful effort to improve its communications with the General Assembly and state officials through its newsletter.

Recommendations

Perhaps the most significant development of the past five years has been the creation of a strong SILO Advisory Council to provide program leadership and assist staff and legislative members in determining objectives and priorities.

•Advisory Council Expansion

The Advisory Council has become critical to the future success of the SILO program. Its members exercise a leadership role in the state's academic institutions, industries, state government, foundations, and non-profit organizations. Their expertise in a variety of fields and endeavors is key to the future of the program. They are uniquely qualified to identify trends, anticipate issues, and lend their collective expertise to the type of creative thinking required by the General Assembly.

The first priority of the SILO program, as it enters its second decade, will be to involve the Advisory Council more closely in establishing the

program's agenda. As a collective body, the Advisory Council has a critical vantage point in anticipating issues likely to surface during the decade. It should also serve as a forum for the creative thinking necessary to tackle those issues.

To accomplish this goal may require some changes in the structure and deliberations of the Council. The Council may want to consider the appointment of subcommittees to handle specific areas of Council inquiry. It is clearly understood that Advisory Council members have heavy commitments and will not normally be able to devote more than a few hours per month to the SILO program. The formation of smaller working groups might, however, make the work of the Council more efficient and actually decrease the amount of time members would be expected to devote to SILO business. Under no circumstances would Advisory Council members be expected to become involved in the minutia of SILO projects. But their background and expertise can be extremely useful in providing solutions to issues facing the Council and - by virtue of their extensive knowledge of certain issues - can create an efficiency in the operation of SILO that would not otherwise be possible.

•Formal Reports And Studies

A procedure to issue formal written reports on various topics considered by the SILO Advisory Council should create a more standardized procedure for dealing with issues and recommendations of the full Advisory Council.

As part of this effort, the following step-by-step approach to issues should be considered:

1. Advisory Council establishes priority issues.
2. Issues are assigned to subcommittee or staff for study
3. Staff prepares research/data materials
4. Staff/subcommittee reports to full Council.
5. SILO conference or seminar held to discuss issue
6. Final written report and recommendations issued by SILO
7. Presentation to General Assembly

There are a number of advantages to this type of process. The full Council takes the initiative in choosing priority issues. The deliberative work is performed in small groups by staff. The issues are handled in a more standardized manner, with a SILO report and recommendations or options as the 'product' of the process. It utilizes many of the procedures now used to deal with matters coming before SILO for resolution, but adds the more formalized report mechanism for presentation of the issue to the General Assembly.

The creation of regular formal SILO reports on important issues - based on research, Council action, and seminars - could provide greater visibility for the SILO program and greater exposure for the issues involved. The reports could also stimulate greater involvement on the part of individual members of the General Assembly.

•Greater Legislative Involvement

As a first step in stimulating greater legislative involvement in the SILO program, members of the Legislative Joint Performance Review

Committee should be asked to serve on individual working groups assigned to specific topics. This not only helps individual legislators to become familiar with the issues, but also helps when these issues are presented to the General Assembly. These members can serve as vital 'advocates' of the report and recommendations and help to explain issues to legislators and legislative committees.

Another way to stimulate greater legislative involvement in the SILO program is to provide a number of small informal working sessions exclusively for legislators on reports issued by SILO. These small sessions would be hosted by Advisory Council members with staff support furnished by the SILO program. An obvious advantage to having sessions sponsored by Advisory Council members is the likelihood that more will attend.

Bureau of Legislative Research staff members assigned to interim committees should also become more actively involved in issues taken up by the SILO program. Their expertise in areas covered by their committees can be invaluable to SILO's deliberations; and they can also become effective 'advocates' for the recommendations adopted by the Advisory Council.

•A Federal Liaison Program - FEDNET

The SILO office should also consider establishing a more formal liaison with the state's Congressional delegation as part of its effort to anticipate issues of future importance to Arkansas. This could take the form of

•regular briefings by Congressional staff members on issues likely to have an impact on Arkansas;

•regular reports by SILO staff on federal developments and regulations likely to have an effect on the state; and

•a 'quick alert' mechanism - **FEDNET** - to disseminate more immediate and critical items of importance.

Since the state does not have an office in Washington, it is important that organizations like SILO have access - on a regular and timely basis - to important federal developments and issues. It would also be useful for Advisory Council members and members of the Arkansas General Assembly to have regular briefings by federal officials and Congressional staff on anticipated developments. Environmental legislation currently under consideration by the Congress, for example, will have a significant impact on Arkansas. Armed in advance with good data on the likely impact of the legislation would enable the SILO program to provide the General Assembly with vital research needed to tackle problems likely to develop when the legislation comes into effect.

The SILO office is ideally situated to provide a formal liaison between the state's General Assembly and the Federal Government. And the knowledge and experience gained through its science/technological liaison service for the General Assembly would enable it to establish the **FEDNET** "advance warning system" without lengthy delay.

It is not anticipated that the office would track every bill, proposed regulation, or federal government initiative that could have an impact on Arkansas. The primary role of the FEDNET liaison program, operated by the SILO office, would be to anticipate major issues likely to have a major impact on the state - analyze those issues, and make the information available to the appropriate legislative committee, state agency, or

interested party. Modern telecommunications and other readily available resources make it practical, inexpensive, and realistic for SILO to consider adding this service.

The SILO program can provide a vital link between the General Assembly and the Congressional delegation, acting as a resource for both the Advisory Council and the legislature itself. The Director's involvement in this effort would be critical to its success, since it would be important to establish a close working relationship with both Congressional staff members and other federal officials. The SILO staff, serving under the Director, would be responsible for normal operation of the program - research, analysis, and reporting.

The SILO newsletter and periodic issue briefs or reports can serve as vehicles for informing the General Assembly and other state officials of future issues and developments, as well as imminent actions. Matters of more immediate or critical concern could be communicated directly to the interested parties by the SILO staff without the intermediate step of a SILO newsletter or issue brief. It would also be possible to solicit from various interested parties matters which they believe should be followed closely by SILO because of possible or likely impact on the state. Staff could also be available to provide expert testimony before legislative committees on developments.

The SILO office could also provide regular briefings for members of the Arkansas General Assembly and their committees on important federal issues. From time to time, it would also be useful to invite members to meet directly with appropriate federal officials - either in Little Rock or Washington. The SILO office would be responsible for scheduling and

making arrangements for such meetings between General Assembly members and appropriate officials.

A formal liaison with the state's powerful Congressional delegation may be more useful than having a state office in Washington. It could also help to increase the influence of the SILO program in both the General Assembly and the State of Arkansas as a whole.

CONCLUSION

There is no doubt that the SILO program has been a success. Few state science and technology programs supported by the National Science Foundation in the late 1970s survived the cutback in federal funding undertaken by the Reagan Administration after 1981. The Arkansas Legislative Project survived. It also managed to expand its agenda to include research topics not directly involved in science and technology. During the past five years, it has expanded its support by undertaking a major development of its Advisory Council. It must now expand the work of the Advisory Council by giving it a leadership role in pinpointing and anticipating issues of future concern to the state of Arkansas and by establishing a close working relationship between the Council and SILO staff and between the Council and legislators. Most important, perhaps, is the need to develop in-house resources to monitor the likely impact of federal developments on the State of Arkansas. The Bush Administration's announced policy of shifting program and financial responsibility to the states requires states - and particularly legislatures - to establish a vehicle for timely and useful data on likely developments. The SILO office is ideally situated to provide that resource.

The Plan for the 1991-1993 Biennium and Beyond

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INTRODUCTION

This planning document, which is presented in two parts, has five sections which outline the Arkansas Science & Technology Authority's background planning data; long-term strategic vision; short-term budget priorities; mission, role and goal statements; and a summary of important conclusions.

Part I includes the summary of important conclusions; mission, role, and goal statements; short-term budget priorities; and long-term strategic vision.

Part II contains the background planning data used to develop the statements in Part I.

The Plan for the 1991-1993 Biennium and Beyond: Part I

I. CONCLUSIONS

It is possible to draw many conclusions from the data collected during this planning effort. For the purposes of the Board of Directors of the Arkansas Science & Technology Authority, the three conclusions of greatest importance are that:

A. Arkansas knows what needs to be done in the area of technology and innovation,
B. Arkansas can perform in these areas, and
C. Arkansas can be a national leader.

First, Arkansas has first-class technology development policy, as indicated by an "A" for technology and innovation policy (with a ranking of 7 out of 50) in the Corporation for Enterprise Development's "The 1990 Development Report Card for the States." This means that Arkansas knows what needs to be done.

Second, the Arkansas Science & Technology Authority (ASTA) represents a six-year experiment in implementing technology and science policy. While ASTA's scale is modest, it has been determined that the projects funded under its programs succeed and can compete with projects anywhere. This means that Arkansas can perform.

Third, ASTA's experimental stage is over; it is time to make the investment in scaling up the programs to meet the critical needs that exist today. Furthermore, while Arkansas has been conducting its experiment and examining state data, it has been found that national data clearly reflect the same image: that bold steps are required for both Arkansas and the nation to address a variety of incredibly important science- and technology-related issues. The states have more experience using science and technology resources for economic development than does the federal government, and Arkansas is part of the states' leadership. This means that Arkansas can lead.

The steps that need to be taken are outlined in the following sections which summarize Board-approved statements of mission, role and scope, goals; budget priorities for the Arkansas Science & Technology Authority for the 1991-1993 biennium; policy options for consideration during the 1990s; and assessments of information about science and technology efforts from around the nation and the globe.

II. MISSION, ROLE, AND GOAL STATEMENTS

A. MISSION. The statutory mission of the Arkansas Science & Technology Authority is to bring the benefits of science and advanced technology to the people and state of Arkansas. The mission is addressed by strategies to promote scientific research, technology development, business innovation, and education--the foundation of science and technology--at all levels.

B. ROLE AND SCOPE. In carrying out its mission and following its strategies, the role and scope of the Arkansas Science & Technology Authority is to serve as a statewide funding resource for the highest quality, competitively judged scientific and technological projects. This role positions the Authority to develop and manage programs that empower others.

The supporting functions of the Authority are data collection and analysis, communication, coordination and planning.

Occasionally, when it is in the state's interest, the Authority will take the lead in developing and implementing specific action agendas.

C. GOALS. There are three major goals of the Arkansas Science & Technology Authority. These goals are:

1. To increase per capita R&D funding at colleges and universities,
   a. By increasing the national competitiveness of Arkansas scientists and
   b. By building a critical mass of research strength in the state.
2. To increase employment, long-term employment growth, long-term job security, and per capita income,
   a. By increasing the investments in applied research, technology development, and business innovation by existing enterprises, thereby preserving and expanding employment opportunities of existing employers, and
   b. By increasing the investments in new, technology-based enterprises, thereby increasing the number of growth-oriented employers.
3. To enhance Arkansas' educational base by increasing support for math, science, and engineering education at all levels.

III. BUDGET PRIORITIES 1991-1993

Budget priorities are presented in two parts: program funds and operating funds.

A. PROGRAM FUNDS. The following budget items include only funds that would be competitively awarded to fund scientific and technological projects under existing or new programs.

RESEARCH PROGRAMS. **The Applied and Basic Research Grant Programs** fund - on a competitive basis - original investigations for the discovery of scientific and technological knowledge. In the Applied Research Grant Program, new equipment and funds from private sources match funds from the Authority; there is a Research and Development Tax Credit for the match. The Science & Technology Authority believes that further development and growth of this program is the single highest priority for the state's technology development effort. Response to, and success of, this program has been exceptional. Since its inception in July 1985, the Basic and Applied Research Grants Program has received 295 proposals and has funded 78 of them. Most of these projects have a direct, long-term effect on the economic vitality of the state of Arkansas. These projects also provide opportunities for other technology development and business innovation programs. The Authority has missed opportunities to fund exceptional research projects with strong economic development potential because of lack of funds. In order for this program to continue supporting basic and applied research efforts in Arkansas colleges and universities, funding must be more readily available.

Recommended Action: Propose funding of $900,000 per year from the General Revenue Fund and $1,800,000 for the biennium from the Capital Improvement Fund.

CENTERS PROGRAM. **The Centers for Applied Technology Program** was established in 1989 to encourage collaborations between institutions of higher learning and private enterprises. The collaborations are intended to speed the discovery, development, and application of new technologies. In 1990 the Centers Program provided matching funds for an award from the National Science Foundation to establish the following three centers: (1) the Center for Protein Dynamics at the University of Arkansas, Fayetteville and (2) the Arkansas Neurobiology Research Center and (3) the Center for Cellular and Molecular Studies on Biological Aging at the University of Arkansas for Medical Sciences. It is anticipated that the NSF program, the Experimental Program to Stimulate Competitive Research (EPSCoR), will continue into 1995 and that matching funds in the amount of $1.5 million per year will be required for the three centers. An additional center with a clear focus on commercialization is needed.

Recommended Action: Propose separate funding to provide the match for the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR).

Related Recommended Action: Request $1.5 million per year from the Capital Improvement Fund to match funds from NSF for the three existing EPSCoR/ASTA centers.

Related Recommended Action: Request $2.4 million for the biennium from the Capital Improvement Fund for Centers for Applied Technology.

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BUSINESS INNOVATION SYSTEM. **The Business Incubator Program** was established in 1985 to foster, in cooperation with colleges and universities, the development of technology-based enterprises. The seventh business incubator was approved in 1990 and marks the final maturation of the Incubator Program, but 1990 also marks the beginning of the Authority's interest in modifying the program, which has focused exclusively on establishing facilities, into an innovation system that better serves small businesses and takes the lead in fostering cooperation among several programs that also serve small businesses. The comprehensive **Business Innovation System** will provide (1) space and shared services, (2) technological assistance, (3) management assistance, and (4) financial assistance. The System is designed to use cooperative efforts to meet small business needs by accessing resources of the Authority, the Small Business Development Center, the projects funded under the Department of Higher Education's economic development program, and the Arkansas Industrial Development Commission. This System is necessary for the expanding support for small businesses and for the voluntary coordination of services for simplicity and efficiency.

Recommended Action: Propose new rules that would convert the incubator network into a Business Innovation System, a coordinated, comprehensive economic development effort comprised of seven distinct innovation centers. The rules would establish accountability of the innovation system and define the voluntary interface with other projects and programs.

Recommended Action: The total proposed budget is $2,000,000. Request separate funding for the modified program of $500,000 per year from the General Revenue Fund and $1,000,000 for the biennium from the Capital Improvement Fund.

TECHNOLOGY DEVELOPMENT. **The Technology Development Program** was approved in 1989. Experience in dealing with inquires from inventors, scientists, and business owners with new product plans, confirms the desperate need for a program to support the development of new ideas. Other programs of the Authority and other state agencies cannot meet this unique need with existing programs, so these ideas languish and some migrate to other states in search of funds. In either case, Arkansas loses valuable opportunities for creating new businesses and new jobs. The purpose of the Technology Development Program is to support the development of innovative technology and prototypes, which can be useful in raising investment capital and licensing new technology to a production company. The authorizing legislation establishes a payback provision for successful technology development projects. The payback is through a royalty of up to five percent of net sales revenue per year for up to 10 years.

Recommended Action: Request $250,000 per year from the General Revenue Fund. This would be the first funding received by this program, which was authorized in 1989.

SEED CAPITAL FUND: **The Seed Capital Investment Program** invests in the scientific and technological projects of small, Arkansas-based, start-up companies. This is the capstone program of the Authority because such companies are launched and their jobs are created as a result of research and development projects of a type which are funded under other Authority programs. The Seed Capital Investment Fund (a cash fund) received a one-time appropriation of $1,800,000 in 1985 from the interest on the general revenue fund. Because of the relatively small size of the Investment Fund, the program uses a 1 to 3 dollar match preference which allows for leveraging these limited investment dollars. The program has invested over $1 million and has leveraged an additional $4.2 million from other sources for a total financing of $5.2 million. The six investments, two in 1990, have created over 124 new jobs in Arkansas. With the increase in the quality of applicants and the experienced program staff, the Seed Capital Investment Program is prepared to take a more aggressive marketing approach, which should generate three to five deals per year with the potential to create hundreds of jobs, but it is imperative that the Investment Fund be increased by $2 million to support the anticipated increased deal flow.

> Recommended Action: Request an additional $2 million for the Seed Capital Investment Fund. It is anticipated that these funds would be appropriated from the interest on the average daily balance of state treasury funds (using special language developed for the original seed capital appropriation).

INFRASTRUCTURE PROGRAM. **The New Science and Engineering Research Infrastructure Grant Program** would be established to improve the quality and quantity of equipment and facilities that are used for research and development activities at colleges and universities, thereby increasing the capacity of the campus to support research.

> Recommended Action: Recommend the creation of a science and engineering research infrastructure program to improve the quality and quantity of equipment and facilities for research and development at colleges and universities. Request $3.6 million for the biennium from the Capital Improvement Fund.

EMINENT SCIENTISTS: **The New Eminent Scientist and Engineer Program** would be established to support up to 30 eminent research positions per year. It is estimated that this would eventually cost $3 million per year (at $100,000 per position per year). The research positions would be limited to the three major research campuses: the University of Arkansas, Fayetteville, the University of Arkansas at Little Rock, and the University of Arkansas for Medical Sciences. Considerations include phasing in the program over three years, building in performance standards for the positions, and requiring matching funds.

> Recommended Action: Recommend the establishment of an eminent scientist and engineer program and suggest that it start with 10 positions the first year, 20 the second, and 30 the third year of the program. Request $1 million for FY 92 and $2 million for FY 93 from the General Revenue Fund.

B. **OPERATING FUNDS:** Specific budget recommendations are made in summary form for specific categories and activities.

CONTINUING LEVEL: **General Maintenance and Operations** includes support for a contining level of effort plus required growth, which includes some modest inflationary increases and new requests for extra help and replacement equipment.

Recommended Action: Request continuing level funding in the amount $1,187,443.

ADJUSTMENTS TO CONTINUING LEVEL: **Adjustments to General Maintenance and Operations** include changes that are needed for personnel actions and operational improvements.

Personnel Actions: Unclassifying the president and vice presidents.

Recommended Action: Request that the following positions be changed to unclassified positions (grade 99) at the stated salary level:

Title (current grade)	FY92 Salary	Proposal
President (26)	$49,270	$60,000
VP Research (23)	36,690	48,000
VP Finance (23)	38,203	44,500
VP Management Services (23)	35,613	40,000

This would result in an overall budget increase (over continuing level) of $81,338 in salaries and match for the biennium.

Operational Improvements: The following maintenance and operations budget items include funds for the fiscal and communications operations and for the modified Business Incubator Program.

Recommended Action: Request a new position to assist with any increased financial responsibility. The position is Accountant I (grade 15) with salary and match of $19,066 for FY92.

Recommended Action: Request a new position to expand the communications effort. The most efficient way to accomplish this is to separate research responsibilities from the existing from the Communications Manager and request a position to assist with data collection and analysis. The position is Management Project Analyst (grade 19) with salary and match of $24,599 for FY92.

Recommended Action: Request a new position to staff the modified Business Incubator Program. This program has never had a program manager, which will be required if the program is modified and made into a coordinated, comprehensive economic development effort. The position is Technology Program Manager (grade 22) with salary and match of $29,118 for FY92.

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Request operating funds to support the new positions at about $9,000 per position per year, plus $4,500 travel per year, and one-time equipment costs of $12,000.

This would result in an overall budget increase (over continuing level) of $225,629 for the biennium.

C. **SUMMARY TABLE:** The budget priorities for the Arkansas Science & Technology Authority for the 1991-93 biennium are shown in Table 1.

TABLE 1. SUMMARY TABLE: BUDGET PRIORITIES FOR THE BIENNIUM

	General Revenue Fund	Capital Improvement Fund
Program Funds:		
Research	1,800,000	1,800,000
Centers		2,400,000
EPSCoR		3,000,000
Innovation System	1,000,000	1,000,000
Tech Development	500,000	
Seed Capital Fund	2,000,000 *	
Infrastructure		3,600,000
Eminent Scientists	3,000,000	
TOTAL PROGRAM FUNDS	8,300,000	11,800,000
Operating Funds:		
Continuing Level	1,187,443	
Adjustments:		
Personnel Actions	81,338	
Operational Improvements:		
3 New Positions and Match	147,629	
Support Funds	66,000	
Support Equipment	12,000	
TOTAL OPERATING FUNDS	1,494,410	
TOTAL FUNDS	9,794,410	11,800,000
GRAND TOTAL FOR THE BIENNIUM FROM ALL SOURCES		**21,594,410**

*Special language required.

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IV. STRATEGIES AND PROGRAMS CONSIDERED: ASTA'S STRATEGIC VISION

The Board of Directors of the Arkansas Science & Technology Authority reviewed and ranked the importance of 25 strategies for technology and economic development in early 1990. The 25 strategies (discussed in greater detail in the section on External Assessment) are divided among five general areas:

1. Building the state's research base,
2. Transferring technological advances,
3. Supporting new enterprise development,
4. Deploying new technologies to existing manufacturers, and
5. Supporting math, science, and engineering education.

The Board selected 17 strategies for discussion and potential Board action. These 17 strategies define the 1990 Board's strategic vision for ASTA and form the foundation for the Board's recommendations for the 1991-1993 biennium.

The strategies and programs considered by the Board at the planning session are outlined below. The identification code (R.1, for example) refers to the strategies discussed in greater detail in the next section.

A. FUNDING ADDITIONAL RESEARCH (R.1)

EXISTING PROGRAM: **Basic Research Grant Program**

Strategy: Use state funds as an incentive to get scientists active in new areas of research, provide them with the beginning of a track record, help them become nationally competitive, and bring more research funds to the state.

Indicators: The amount of research funds attracted by the scientist (short-term) and total R&D funds in universities (long-term).

Potential Actions [for R.1 & T.3]: Propose funding of $900,000 a year from the General Revenue Fund and $900,000 a year from the Capital Improvement Fund.

B. RECRUITING FEDERAL OR PRIVATE-SECTOR RESEARCH INSTITUTIONS (R.2)

EXISTING PROGRAM: **SBIR Assistance Program**

Strategy: Promote the federal SBIR program and provide assistance to small businesses which want to submit proposals. This will increase the amount of federal R&D funds coming to Arkansas.

Indicators: Total R&D funds from federal agencies participating in the SBIR program.

Potential Actions: Request a new position for a technical editor who would help write SBIR proposals.

EXISTING PROJECT: **Corridor Development Project**

Strategy No. 1: Increase the capacity of NCTR to address the international competitiveness of the U.S. biotech industry. Successful implementation of NBC by the federal government will influence:

1. Enhanced research capacity in universities in general (and UAF, UAMS, UALR, UAPB, NCTR-AU in particular) with both federal and private funds,
2. Improved faculties, and
3. Development of a high-tech base in new and existing firms in the biotech, agricultural, and environmental sectors of the economy.

Indicators: Number of new products developed, number of new companies, venture capital investments (short-term), number of patents issued, employment, employment growth, and total R&D funds in universities (long-term).

Potential Actions:

1. Complete the feasibility study and master plan for the National Biotechnology Cooperative (NBC) at NCTR.
2. Request a state appropriation to implement NBC using the state's agenda. This would require a plan to give direction and leadership to the project and which would be used to gain political support.

Strategy No. 2: Implement a corridor development plan that, while building on the feasibility study and master plan for NBC, would be responsive to the state's economic development agenda, yet complement NBC.

Indicators: The feasibility study and master plan, the state's corridor development plan and action agenda, matching funds from private sources and participation by other state agencies in the implementation of the plan. Ultimate indicators are the number of new products developed, number of new companies, venture capital investments (short-term), number of patents issued, employment, employment growth, and total R&D funds in universities (long-term).

Potential Actions: Develop the corridor development plan and promote its implementation. Focus on agriculture-related research, alternate fuels (i.e., ethanol), value added agricultural products, waste disposal, environmental issues (e.g., clear-cutting, paper recycling, drinking water quality, poultry waste). Don't copy efforts from other parts of the country; rather seek world leadership in a unique niche. Take advantage of enhanced the Little Rock airport.

PROPOSAL: **Coordinating Office**

Strategy: Increase the opportunities for colleges and universities to participate in federal R&D activities.

Indicators: The amount of research funds attracted by the campuses (short-term) and total R&D funds in universities (long-term).

Potential Actions: Request two professionals and one support person to staff a new coordinating

office. Determine the level of operational support. Define the specific recruiting effort and show the need for it. Develop the plan for establishing a coordinating office to serve as a clearinghouse which would match federal opportunities in R&D with strengths in the Arkansas' colleges and universities.

Related Potential Action: Recommend amending the definition of manufacturing. Some state and federal programs do not assist service companies because the definition of manufacturing does not include services and related production activities.

C. ENACTING TAX INCENTIVES FOR CORPORATE RESEARCH (R.4)

EXISTING PROGRAM: **R&D Tax Credit Program**

Strategy: (This strategy is related to the existing Applied Research Grant Program.) Use state matching funds as an incentive (1) to get scientists active in lines of applied research and (2) to encourage partnerships with industry; provide industry with new technology that secures and expands employment; provide scientists with the beginning of a track record; help them become nationally competitive and bring more research funds to the state; and build the capacity to rapidly commercialize research results.

Indicators: Value of tax credits issued and number of applied research grants.

Potential Actions: None.

Related Potential Action: Recommend a tax exemption for university purchases of research equipment. (Should this apply just to ASTA grants?) Develop model legislation.

D. CREATING INDUSTRY-UNIVERSITY RESEARCH CENTERS (T.2)

EXISTING PROGRAM: **Centers for Applied Technology**

Strategy: Build a critical mass of research strength in selected disciplines and complement it with efforts to rapidly commercialize research results.

Indicators: The amount of research funds attracted by the centers, private matching funds raised by the centers, new products developed (short-term), total R&D funds in universities, and number of patents issued (long-term).

Potential Actions: Propose separate public funding for the matching funds for the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR).

Related Potential Action: Request $1.2 million a year from the Capital Improvement Fund for Centers for Applied Technology.

Related Potential Action: Request $1.5 million a year from the Capital Improvement Fund to match funds from NSF for the three existing EPSCoR/ASTA centers.

E. AWARDING MATCHING GRANTS TO INDUSTRY-UNIVERSITY PROJECTS (T.3)

EXISTING PROGRAM: **Applied Research Grant Program**

Strategy: Use state matching funds as an incentive (1) to get scientists active in lines of applied research and (2) to encourage partnerships with industry; provide industry with new technology that secures and expands employment; provide scientists with the beginning of a track record; help them become nationally competitive and bring more research funds to the state; and build the capacity to rapidly commercialize research results.

Indicators: The amount of research funds attracted by the faculty, private matching funds raised by the projects (short-term), employment, employment growth and total R&D funds in universities (long-term).

Potential Actions: See potential actions for the Basic Research Grant Program [A.(R.1)].

F. CREATING RESEARCH INSTITUTIONS THAT FILL THE GAP BETWEEN ACADEMIA AND BUSINESS (T.5)

EXISTING PROGRAM: **Technology Development Program**

Strategy: Use state funds as an incentive to develop prototypes and to protect intellectual property. Prototypes and patents are the earliest phases of technology development and are not covered by any other state programs. New business opportunities, with related employment and growth potential, would result and feed into other state supported business assistance programs.

Indicators: Number of new products developed (short-term), number of patents issued, new companies, employment, and employment growth (long-term).

Potential Action: Request $500,000 for biennium. This would be the first funding received by this program.

G. CREATING SEPARATE TECHNOLOGY TRANSFER ORGANIZATIONS SPECIFICALLY DESIGNED TO IDENTIFY PROMISING RESEARCH RESULTS AND ASSIST IN THEIR COMMERCIALIZATION (T.7)

EXISTING PROGRAM: **Technology Transfer Program**

Strategy: Spin off a private, not-for-profit development arm to facilitate cooperation between public and private entities, and to shelter early-stage development projects funded by ASTA.

Indicators: Number of projects funded, number of transfers completed, number of new products developed, return on investment, (short-term), number of patents issued, new companies, employment, and employment growth (long-term).

Potential Action: Modify the context of the Technology Transfer Program by creating a 501(c)(3) organizational entity for long-range product and business development. (The Board would raise the money for this effort.)

H. ENSURING AN ADEQUATE SUPPLY OF RISK CAPITAL (N.1)

EXISTING PROGRAM: **Seed Capital Investment Program**

Strategy: Use public funds to invest in the innovative technology of Arkansas enterprises and serve as an incentive for technology and business development in Arkansas.

Indicators: Number of investments made, number of new products developed, return on investment, (short-term), number of patents issued, new companies, employment, and employment growth (long-term).

Potential Action: Request an additional $2 million for the Seed Capital Investment Fund and request one new position to serve a more proactive role in promoting the program.

I. CREATING SMALL BUSINESS INCUBATORS TO INCREASE THE SURVIVAL RATE OF TECHNOLOGY START-UPS (N.2)

EXISTING PROGRAM: **Business Incubator Program**

Strategy: To provide the sheltered, university-affiliated environment in which new, technology-based enterprises would experience an increased business survival rate.

Indicators: Number of tenant companies, number of employees, number of new products developed, number of companies in which Seed Capital Investments are made and the associated return on investment (short-term), number of patents issued, new companies, employment, and employment growth (long-term).

Board Discussion: The Board discussed the Incubator Program at length. It was observed by staff that the program is currently operating under an informal seven-year plan which will eventually sunset incubators that cannot become self-sustaining. Self-sufficiency is not likely. If political support for the program is generated by the incubators, ASTA may receive funds for the program anyway and pass them through to the campuses.

- One proposal is to transfer incubators without walls to the jurisdiction of the 10/10 program at the Department of Higher Education and to plan the "graceful" sunset of the others remaining at ASTA.

Another proposal is to modify the program in a more radical way, for instance, by turning incubators into business innovation centers.

Proposed Action: Request funds to obtain business and engineering assistance for new businesses regardless of tenancy in an incubator. Base such a request on a survey asking incubator managers how much such expertise is needed. The performance of tenants indicates there is some need for such assistance. Determine the unit cost for such help.

Proposed Action: Recommend the transfer of incubators without walls to Arkansas Department of Higher Education's 10/10 program. Sunset other incubators according to some plan.

Related Potential Action: Recommend to the Arkansas Department of Higher Education that 10/10 awards for small business assistance projects should go to the state Small Business Development Center office for coordination with SBDCs around the state.

Proposed Action: Recommend separate funding for incubators.

Action: Because of the differing opinions of its members, the Board established a task force to examine the incubator program and the associated issues and report back to the Board.

Task Force Discussion: The task force met and discussed several options. This constitutes its report.

The first basic conclusion is that the Board has seen the incubator projects drift from the original technology-development intent of the program. The number of differing opinions about the program's future can be reduced to two:

1. Allow the program to sunset because it has drifted off course or
2. Restructure the program to bring it back on course. The second basic conclusion is that the correct and more difficult choice is the one that involves restructuring.

The restructuring option involves modifying the Business Incubator Program by creating the Business Innovation System. BIS would be established out of the seven existing incubator efforts.

The incubators shelter a wide variety of business services. These existing services can be put into four categories:

1. Space in an incubator facility and shared business services for tenants.
2. Technological assistance provided by universities. (This was ASTA's original focus with the incubator program. Technological assistance is generally offered to the incubator tenants through engineering colleges. When the services extend beyond the campus, the effort takes on the appearance of an industrial extension service.)
3. Management assistance provided by universities. (It is known, and has been verified by the incubator program, that management is more important to a new business than capital. Traditional management assistance programs have had too limited vision. The most successful at management assistance work with relatively few clients, who are selected after careful screening and found to have growth potential. This kind of help would not be for firms in serious trouble.)
4. Financial consulting and clearinghouse activities. (This is the predominant type of business assistance provided in Arkansas. It includes loan packaging and business training (SBDCs), seed capital and venture capital referrals (10/10 projects and SBDCs), and banking connections.)

The restructuring option must create a comprehensive innovation system out of the original seven incubators. The system must be able to respond to clients, refer clients to other resources, visit clients anywhere in the state, and offer every client access to comprehensive business innovation services.

Comprehensive business innovation services would include:

1. Space and shared business services,
2. Technological assistance,
3. Management assistance, and
4. Financial consulting.

The following specific activities would be divided among these four service areas:

A. Space acquisition
B. Shared business services
C. Access to ASTA's business programs
   1. Applied Research Grant Program
   2. SBIR Assistance Program
   3. Technology Development Program
      a. Prototypes
      b. Intellectual property
   4. Seed Capital Investment Program
D. Technology transfer services
   1. Diagnosis of need and assessment of technology in industry
E. Consultants
   1. Engineering
   2. Management
   3. Financial
F. Training
   1. Business managements
   2. Vocational skills
   3. Regulatory issues (i.e. IRS, OSHA)
G. Referrals and inventory of other resources

Furthermore, the following economic development programs have potential connections to an extended economic development network which would also include the Business Innovation System:

A. ASTA's business-related programs at ASTA
B. Quality management at the Arkansas Industrial Development Commission
C. Minority business development at AIDC
D. Business development loans at the Arkansas Development Finance Authority
E. Business assistance and training at Small Business Development Centers
F. Economic development projects funded through the 10/10 program and the Arkansas Department of Higher Education
G. Technology transfer at Arkansas Center for Technology Transfer (a 10/10 project at UAF)
H. Management assistance at the Entrepreneurial Service Center (a 10/10 project at UAF).
I. Industrial coordinators at the VoTech Division

MODIFIED PROGRAM: **Business Innovation System**

Strategy: Provide leadership and partial funding for seven business innovation centers that would comprise a statewide system providing business, technological, and managerial assistance for small or technology-based enterprises.

Indicators: Number of tenant or client enterprises, number of employees, number of new products developed, number of enterprises participating in other ASTA programs (short-term), number of patents issued, number of new companies, employment, and employment growth (long-term).

Recommended Action: Propose new rules that would convert the incubator network into a business innovation system. The rules would establish accountability of the innovation centers and define the voluntary interface with other projects and programs.

J. CREATING INDUSTRIAL EXTENSION SERVICES (M.1)

PROPOSAL: **Industrial Extension Service**

Strategy: Not explored in detail.

Indicators: Not identified.

Potential Action: Establish an Industrial Extension Service

Board Discussion: This is a good idea, but premature for the 1991-93 biennium. The Arkansas Center for Technology Transfer might be expanded into a formal Industrial Extension Service.

K. CREATING OR SUPPORTING RESEARCH INSTITUTIONS ON MANUFACTURING THAT DOUBLE AS CONSULTING ORGANIZATIONS TO MANUFACTURING BUSINESSES (M.2)

PROPOSAL: **Manufacturing Institute**

Strategy: Not explored in detail.

Indicators: Not identified.

Potential Action: Establish a Manufacturing Institute.

Board Discussion: The creation of a manufacturing institute is a good idea, but premature at this time.

L. SETTING UP A LOAN FUND FOR MATURE MANUFACTURERS, BACKED BY TECHNICAL ASSISTANCE (M.3)

PROPOSED PROGRAM: **Management and Technology Assistance Program**

Strategy: Use public resources and other public programs to increase employment, employment security, and decrease business failure rate. In practice, the strategy would seek industry-preferred research and development projects. The projects would be cost sharing and would perhaps involve a loan program for manufacturing modernization. Massachusetts has such a program and over two years has made 19 loans totaling $4.4 million.

Indicators: The number of projects undertaken (short-term), employment, long-term employment growth, business failure rate, and manufacturing capital investment (long-term).

Potential Action: Request (1) the establishment of the Management and Technology Assessment Program and (2) one or two new positions to implement the program.

Board Discussion: This proposal resembles the proposed coordinating office

M. CREATING REGIONAL NETWORKS WITHIN THE SAME INDUSTRY TO WORK TOGETHER TO MEET TECHNOLOGY NEEDS (M.4)

PROPOSED PROGRAM: **Arkansas Industrial Network Program**

Strategy: Bring together small companies from the same region and within the same industry for mutual support and economies of scale.

Indicators: Number of networks, number of participating companies (short-term), employment, and employment growth (long-term).

Board Discussion: The network project is a good idea, but ASTA doesn't have the resources for this type of program. Perhaps ASTA could recommend another agency to take the lead on this project. The Arkansas Industrial Development Commission would appear to be the logical agency.

N. ESTABLISHING A CENTER FOR SCIENCE EDUCATION (E.1)

PROPOSAL: **Center for Science Education**

Strategy: Improve primary and secondary math and science education by establishing a resource and clearinghouse for math and science teachers statewide.

Indicators: Number of inquiries handled, number of grants received (short-term), and science and engineering students per 1000 population (long-term).

Board Discussion: There is concern about whether ASTA is the proper agency to establish such a center. There is a clear need for such a resource as demonstrated by the dismal statistics for U.S. performance in math and science compared to students abroad. If other agencies do not take steps to establish such a center, ASTA may have to propose implementing a science education program. In the meantime ASTA should be an advocate for improving math and science education and do what it can to support math and science education.

Potential Action: Restructure research grants for basic and applied research projects to encourage collaborations at all educational levels.

Potential Action: Recommend that Arkansas Department of Higher Education and the Arkansas Department of Education support science education.

O. SUPPORTING ENGINEERING FOR THE DELTA (E.2)

PROPOSED PROGRAM: **Science and Engineering Scholarship Program**

Strategy: Use public funds as an incentive for minority and women students from the Delta to go into college-level science and engineering programs and to return to the Delta for a required period of public service (in lieu of repaying the scholarship) and to provide other students with role models.

Indicators: Number of scholarships and public service tours (short-term), number of female and minority scientists and engineers, science and engineering students per 1000 population, science and engineering degrees granted, scientists and engineers in the work force (long-term).

Board Discussion: There is concern about whether ASTA is the proper agency to establish such a scholarship program. There is a clear need for such a program, as demonstrated by the analyses of the National Science Foundation and others. If other agencies do not take steps to establish such a scholarship program, ASTA may propose implementing such a program. In the meantime ASTA should be an advocate.

Potential Action: Propose a science and engineering scholarship program for qualified students in the Delta. Determine how much such a program would cost ($20,000 per student for four years or $5,000 per year), how many students could be supported (phase in, start with five or 10), how long the scholarship would last (four years), and what length of public service would be required of the recipient upon graduation (one year). Perhaps this program should be located in a new science and technology foundation.

P. SUPPORTING HIGHER EDUCATION INFRASTRUCTURE FOR SCIENCE AND ENGINEERING (E.3)

PROPOSED PROGRAM: **Science and Engineering Research Infrastructure Program**

Strategy: Improve the quality and quantity of equipment and facilities that are used for research and development activities at colleges and universities, thereby increasing the capacity of the campus to support research.

Indicators: Number and amount of awards for equipment and facilities, the amount of research funds attracted by the campus (short-term), science and engineering students per 1000 population, science and engineering degrees granted, scientists and engineers in the work force, and total R&D funds in universities (long-term).

Board Discussion: Recommending infrastructure and equipment funds is the job of the Arkansas Department of Higher Education. There is concern about whether ASTA is the proper agency to operate an infrastructure program. If infrastructure needs are not otherwise met, ASTA may propose implementing a science and engineering research infrastructure program to support ASTA's existing research and centers programs.

Q. SUPPLEMENTING HIGHER EDUCATION MANPOWER (E.4)

PROPOSED PROGRAM: **Eminent Scientist and Engineer Program**

Strategy: Provide support for eminent research positions at colleges and universities. This would improve the research manpower situation at the research institutions and make them more nationally competitive.

Indicators: Number of awards and the amount of research funds attracted by the campus (short-term), science and engineering students per 1000 population, science and engineering degrees granted, scientists and engineers in the work force, and total R&D funds in universities (long-term).

Board Discussion: There is concern about whether ASTA is the proper agency to establish such a program, however, if science and engineering manpower needs are not otherwise met, ASTA may propose implementing an eminent scientist and engineer program.

Potential Action: Recommend the establishment of an eminent scientist and engineer program and suggest that it eventually support 30 eminent research positions per year. It is estimated that this would cost $3 million per year. The research positions would be limited to three campuses: UAF, UAMS, and UALR. Consider phasing in the program, building in performance standards for the positions, and requiring matching funds.

R. SUPPORTING PROGRAMS (S.2)

EXISTING SUPPORTING PROGRAM: **Planning**

Strategy: ASTA must maintain a clear strategic direction for its programs.

Indicators: Sound statements of mission, role and scope, goals.

Potential Action: Recommend annual planning sessions with the Board of Directors.

PROPOSED SUPPORTING PROGRAM: **Evaluation**

Strategy: ASTA must be able to determine how closely activities match its strategic direction.

Indicators: Analysis of short- and long-term strategic indicators.

Board Discussion: How does ASTA evaluate the performance of its programs? What counts: jobs, projects, research funds? There are two levels of information: very detailed and anecdotal.

Potential Action: Recommend that ASTA's staff, under the direction of the Planning Committee, identify, monitor, collect, analyze, and report information suggested in this report as indicators of program performance. This activity will eventually require the request for a new position.

EXISTING SUPPORTING PROGRAM: **Communications**

Strategy: Bringing the benefits of science and advanced technology to the people of Arkansas requires a strong communications program to communicate opportunities and accomplishments to policy makers and the public.

Indicators: Public awareness, media clippings (short-term), and public attitudes (long-term).

Potential Action: Request a new communications position to expand the communications effort (from the existing base of the Annual Report and quarterly newsletter) to include the dissemination of analytical, planning, and evaluation information to the media, other public agencies, and private enterprises.

EXISTING SUPPORTING PROGRAM: **Fiscal**

Strategy: ASTA must have strong fiscal management.

Indicators: Number of transactions and state audits.

Potential Action: Request a new position to assist with any increased financial responsibility. ASTA's fiscal capacity is strained with its current programs' activities. If existing programs are strengthened or new programs are added, ASTA's fiscal capacity will be inadequate.

The Plan for the 1981-1993 Biennium and Beyond: Part II

V. BACKGROUND PLANNING MATERIAL

The following sections provide most of the information provided by ASTA's staff to the Board of Directors for its planning effort. These sections include:

A. A brief history of the Arkansas Science & Technology Authority,
B. A summary of the internal agency environment in terms of programs and projects, and
C. A presentation of the external environment in terms of technology development strategies used elsewhere and the Board of Directors' evaluation (ranking) of these strategies.

A. HISTORY

The Arkansas Science & Technology Authority was created in 1983. The conceptual foundation for the Authority was included in a report submitted to the Legislative Council by a blue-ribbon task force.

The members of the task force envisioned an entity which "would serve a number of essential purposes in Arkansas." Ten such potential purposes were outlined:

1. Determine emerging technologies, make comprehensive recommendations so as to create the environment for scientific, economic, educational, and research development;

2. Prepare comprehensive reports on political climate, work force, venture capital sources, and educational resources;

3. Serve as the primary coordinating mechanism for greater ease in entering into contractual or service relationships with state government, educational institutions, and industry;

4. Sponsor conferences in new areas of science and technology;

5. Analyze the impact of taxes and regulation on high technology development;

6. Identify and develop contact with research and development funding sources;

7. Maintain a statewide inventory of major scientific equipment, personnel, and R&D activity in the state;

8. Serve as dissemination clearinghouse;

9. Identify needed research or educational programs;

10. Provide seed funding for research projects.

The General Assembly created the Arkansas Science & Technology Authority with Act 859 of 1983 and gave the new Authority the mission to gain the benefits of advanced science and technology for the people of Arkansas. The Act empowered the Authority to make contracts, acquire and dispose of real estate, enter into agreements, invest funds, borrow money, accept grants and donations, trade securities, finance and conduct investigations, prepare and publish technological studies and reports, organize and conduct conferences, own patents, provide scientific and technological data and information, study and develop plans and programs in the sciences and technologies to support industrial development, recommend legislation and issue revenue bonds. (The authority to issue revenue bonds was removed by Act 409 of 1985 and given in another Act to the then newly crafted Arkansas Development Finance Authority.)

The Authority's first activities in 1984 involved planning and a comprehensive inventory and information effort. This was followed in 1985 with the General Assembly's enactment of Governor Bill Clinton's economic development programs.

Act 409 of 1985 amended the Authority's original legislation by adding four new programs that would enable the Authority to provide financial assistance to technology-based industries and to support basic and applied research in Arkansas colleges and universities. These programs include the Seed Capital Investment Program, the Business Incubator Program, the Technology Transfer Program, and the Basic and Applied Research Grants Program. Act 740 of 1985 created the Research and Development Tax Credit for cash and new equipment used as a private match for the Applied Research Grant Program.

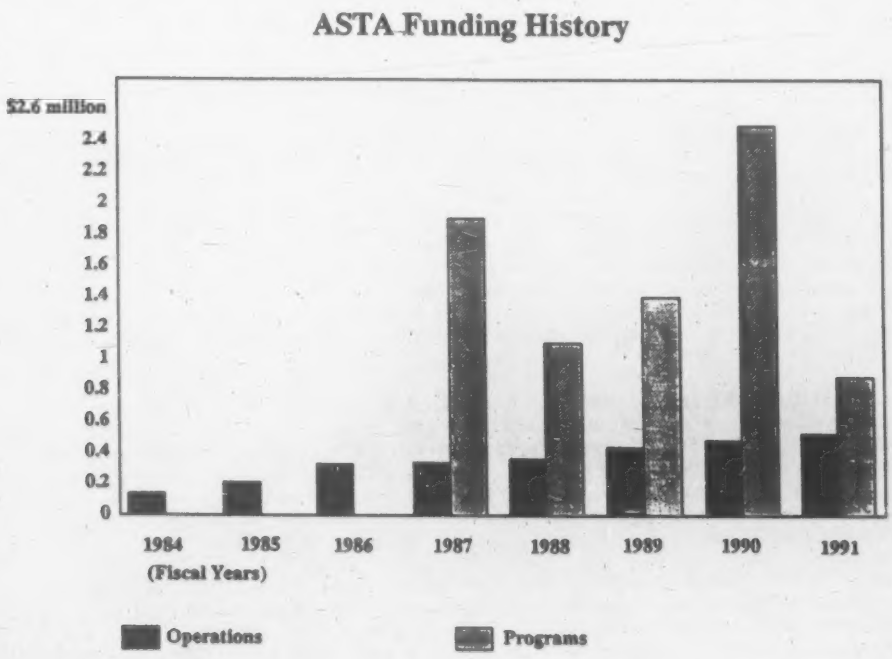
Act 210 of 1987 further amended the Authority's legislation and expanded the Authority's programatic activities to include providing assistance to small businesses, helping them to identify and apply for funds under the federal Small Business Innovation Research (SBIR) Program. This federal program provides competitive grants to small businesses to research and develop innovative technology needed by the federal government. The Authority's SBIR Assistance Program monitors the technology needed by the federal government, publicizes this need, and helps small Arkansas businesses compete for the federal funds.

Act 803 of 1989 amended the Authority's legislation to include a new Centers for Applied Technology Program. The original intent of the amendment was to create university-based centers where the results of scientific research could be more rapidly commercialized. Late in the regular session, the intent was modified so that program funds could be used to match $1.2 million in federal funds from the National Science Foundation under its Experimental Program to Stimulate Competitive Research (EPSCoR). The joint federal and state budget has suppoted three centers since mid-1990.

Act 271 of 1989 added the Technology Development Program to the Authority's enabling legislation. This Act is especially significant because it adds a program that fills a gap between other programs. The gap is the one in which inventors, scientists and small businesses often find themselves; they have a good idea, but they don't have the modest resources to take the idea to the next stage of development. This program allows the Authority to invest up to $50,000 in the development of a working prototype. The legislation also allows the Authority to negotiate royalty paybacks of up to five percent of net sales for 10 years. Unfortunately, this important program was not funded in 1989.

A summary of the Authority's appropriation history is presented in the following chart.

Figure 1.



B. ANALYSIS OF THE INTERNAL ENVIRONMENT

A great deal of material about the existing programs of the Arkansas Science & Technology Authority was assembled and reviewed by the Board of Directors at its March 16, 1990, meeting.

In brief, the Board found that the Authority had accomplished more in its six-year history than anyone expected. The Board approved over 90 projects that invested over $7 million in research, development, and innovative businesses. Each of the Authority's programs has major success stories that show the value of the state's effort to develop its scientific, engineering, and technological resources.

Among the data reviewed by the Board were detailed program commentaries, program statistics, success stories, and program organization. Some of this information is summarized here.

PROGRAM COMMENTARY. The Science & Technology Authority currently conducts five major programs. These include the Basic and Applied Research Grants Programs, the Seed Capital Program, the Business Incubator Program and the Centers for Applied Technology Program. In addition to these, the Authority also manages an SBIR Assistance Program and a Technology Transfer Program. Besides programs, the Authority also (1) undertakes special demonstration projects, such as the National Biotechnology Cooperative, which are identified as priorities by the Authority's Board of Directors, (2) maintains liaison on matters of science and technology with the state legislature and Arkansas' Congressional delegation, and (3) carries out supporting functions involving data collection and analysis, communication, coordination, and planning activities.

The Basic and Applied Research Grants Programs fund - on a competitive basis - original investigations for the discovery of scientific and technological knowledge. In the Applied Research Grant Program, new equipment and funds from private sources match funds from the Authority; there is a Research and Development Tax Credit for the match. The Science & Technology Authority believes that further development and growth of this program is the single highest priority for the state's technology development effort. Response to, and success of this program, has been exceptional. Since its inception in July 1985, the Basic and Applied Research Grants Program has received 295 proposals and has funded 78 of them. Most of these projects have a direct, long-term effect on the economic vitality of the state of Arkansas. These projects also provide opportunities for other technology development and business innovation programs. The Authority has missed opportunities to fund exceptional research projects with strong economic development potential because of lack of funds. In order for this program to continue supporting basic and applied research efforts in Arkansas colleges and universities, funding must be more readily available.

The Seed Capital Investment Program invests in the scientific and technological projects of small, Arkansas-based, start-up companies. This is the capstone program of the Authority because such companies are launched and their jobs are created as a result of research and development projects of a type which are funded under other Authority programs. The Seed Capital Investment Fund (a cash fund) received a one-time appropriation of $1,800,000 in 1985 from the interest on the general revenue fund. Because of the relatively small size of the Investment Fund, the program uses a 1 to 3 dollar match preference which allows for leveraging these limited investment dollars. The program has invested over $1 million dollars and has leveraged an additional $4.2 million dollars from other sources for a total financing of $5.2 million dollars. The six investments, two in 1990, have created over 124 new jobs in Arkansas. With the increase in the quality of applicants and the experienced program staff, the Seed Capital Investment Program is prepared to take a more aggressive marketing approach, which should generate three to five deals per year with the potential to create hundreds of jobs, but it

is imperative that the Investment Fund be increased by $2 million dollars to support the anticipated increased deal flow.

The Business Incubator Program was established in 1985 to foster, in cooperation with colleges and universitiesd, the development of technology-based enterprises. The seventh business incubator was approved in 1990 and marks the final maturation of the Incubator program, but 1990 also marks the beginning of the Authority's interest in modifying the program, which has focused exclusively on establishing facilities, into an innovation system that better serves small businesses and takes the lead in fostering cooperation among several programs that also serve small businesses. The comprehensive business innovation system will provide (1) space and shared services, (2) technological assistance, (3) management assistance, and (4) financial assistance. The system will meet small business needs by using resources of the Authority, the Small Business Development Center, the projects funded under the Department of Higher Education's economic development program, and the Arkansas Industrial Development Commission. This system is necessary for the expanding support for small businesses and for the voluntary coordination of services for simplicity and efficiency.

The Centers for Applied Technology Program was established in 1989 to encourage collaborations between institutions of higher learning and private enterprises. The collaborations are intended to speed the discovery, development, and application of new technologies. In 1990 the Centers Program provided matching funds for an award from the National Science Foundation to establish the following three centers: (1) the Center for Protein Dynamics at the University of Arkansas, Fayetteville and (2) the Arkansas Neurobiology Research Center and (3) the Center for Cellular and Molecular Studies on Biological Aging at the University of Arkansas for Medical Sciences. It is anticipated that the NSF program will continue into 1995 and that matching funds in the amount of $1.5 million per year will be required for the three centers. An additional center with a clear focus on commercialization is needed.

The Technology Development Program was approved in 1989. Continuing experience this biennium in dealing with inquires from inventors, scientists, and business owners with new product plans, confirms the desperate need for a program to support the development of new ideas. Other programs of the Authority and other state agencies cannot meet this unique need with existing programs, so these ideas languish and some migrate to other states in search of funds. In either case, Arkansas loses valuable opportunities for creating new businesses and new jobs. The purpose of the Technology Development Program is to support the development of innovative technology and prototypes, which can be useful in raising investment capital and licensing new technology to a production company. The authorizing legislation establishes a payback provision for successful technology development projects. The payback is through a royalty of up to five percent of net sales revenue per year for up to 10 years.

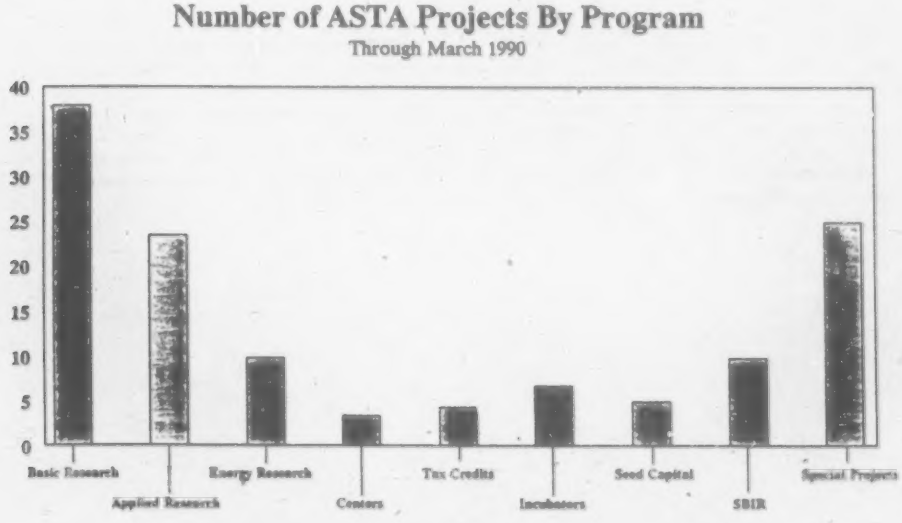
The Technology Transfer Program has provided, since its establishment in 1985, a link between the technological resources of the state's university research centers and private enterprises. The primary goal of this service program has been to help Arkansas business and industry become better prepared for competition in a technologically-driven economy. The Technology Transfer Program functions primarily through referrals to specific technology development programs at the Authority and centers at colleges and universities. A proposal has been submitted to the National Institute for Standards and Technology to expand the Technology Transfer Program to include the transfer of federal technology to Arkansas firms. This proposed project will expand the role that colleges and universities will have in assisting Arkansas industry to develop its technological capacity, thus expanding employment rolls in the state.

The SBIR Assistance Program was established in 1987 to provide services helping Arkansas firms prepare proposals for federal funding under the federal Small Business Innovation Research (SBIR) Program. The Authority for example, assisted a Little Rock business that has been awarded a Phase II grant under this program for $397,542 over a two year period. The Authority is seeking ways to promote the SBIR Program more widely to other small businesses around the state. While programs exist in several other states which supplement the federal SBIR Program with state grant funds that match the federal awards, no such funds are available in Arkansas.

A National Demonstration Project has been identified as a priority of the Authority's Board of Directors for the 1991-93 biennium. This project involves a $1 million cost sharing contract with the Food and Drug Administration to conduct a feasibility study and master plan for the National Biotechnology Cooperative. The site for this national demonstration project is proposed for the National Center for Toxicological Research at Jefferson, Arkansas. It is expected that the contract work will extend through September 1991. The demonstration project is another important step in the development of a science and technology corridor between Little Rock and Pine Bluff, which was considered a legislative priority when the Authority was created in 1983. The demonstration project offers significant development opportunities which can be fostered through programs of the Authority.

PROGRAM STATISTICS. The first statutory programs of the Authority began actual operation in January 1986. Statistics for these programs are shown in the accompanying illustrations. The first illustration shows the total number of projects funded by program.

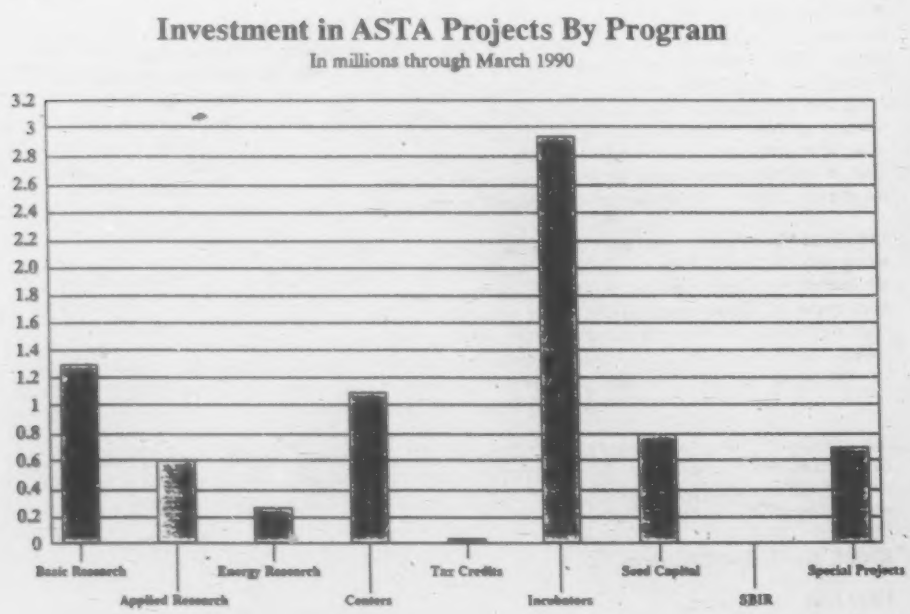
Figure 2.



An explanatory remark is required because this illustration shows a bar labeled Energy, which has not previously been discussed. This label refers to energy-related research projects awarded under the Basic and Applied Research Grant Programs with $300,000 in funds granted to the Authority from the Petrolem Escrow Funds administered by the Arkansas Industrial Development Commission. These awards are shown separately because of the unique source of funds.

The second illustration, using the same program breakdown, shows total expenditures by program.

Figure 3.



There is one note about this illustration; the amount shown for Tax Credits is the total amount of tax credits granted on corporate income tax filings.

PROGRAM SUCCESSES STORIES

Applied Research Grant Program:

Fall Green Spinach: Two ASTA grants totaling $99,220 resulted in the development and commercial release of fall green spinach, a variety with great resistance to disease and environmental stress. The success of this variety has been demonstrated by one spinach processor who has planted 100 percent of its crop with fall green for the last two fall seasons without the application of any fungicide. It is estimated that this variety has resulted in about 600 Arkansas jobs. This success has lead to the development of a similar flat leaf variety of spinach which provides the same disease resistance, but is of more interest to processors such as Gerber, according to Teddy Morelock, principal investigator. This second variety is expected to be released within the next couple of years. The grants were matched by a $164,000 contribution from Allen Canning Co. of Siloam Springs.

Industrial Manufacturing of Chemicals: John Garrison, owner of Garrison Industries of El Dorado, along with Dr. Neil T. Allison and Dr. Norbert Pieta, two University of Arkansas at Fayetteville professors, have developed industrial manufacturing processes for several chemicals, concentrating on nitro organics. These chemicals are custom manufactured for ordering companies. Garrison Industries has recently purchased a manufacturing facility in Ashdown, North Carolina, which will be disassembled and transported to Arkansas to expand the company's present facilities. Nine employees are currently working for the company. The research received two grants for $36,217 and $40,740 from ASTA which Garrison Industries matched with $38,485 in private funds.

Soy Allergenicity: An ASTA grant of $23,075 lead to a $450,000 follow-on grant from the National Institutes of Health to continue research into the soy proteins that can cause allergic reactions. Studies are focusing on the purification of the allergy-causing proteins. The applied research grant was matched by $23,075 from Ross Laboratories.

Basic Research Grant Program:

Knee Joint: This research project is working to develop a faster process for isolating and purifying a lubricating protein found in body joints. A lack of this lubricant is thought to lead to arthritis. A $51,330 ASTA grant indirectly resulted in two NIH grants totaling more than $555,000. Private funding of $12,000 was also awarded by the McCutchen Foundation of New York State. The research also received the First Annual Albert Trillat Award in 1989 from the International Society of the Knee and the Ed Cabaud Award for Excellence in Sports Medicine from the American Orthopaedic Society for Sports Medicine.

Development of New Forest Management Instruments: A $24,695 grant assisted in the development of an instrument for more exact study of the effect light conditions have on plant communities. In the study, an expertise was developed in the design of low-power microprocessor systems that could be used to develop more commercially promising products. Using this knowledge Doug Wilson, a UALR researcher, won a $25,000 grant from the U.S. Forestry Service.

Computer Graphics to Illustrate Molecular Motion: This basic research project, assisted by a $8,950 ASTA grant, makes understanding the principles of physics easier with colorful, two-dimensional moving models which illustrate ideas that would normally be expressed in mathematical terms. Dr. William Harter of UAF used the computer graphic illustrations to investigate molecular rotations and vibrations. Results from his study were included in 14 publications.

Seed Capital Program:

Artek Systems, Inc.: This most recent ASTA Seed Capital investment has proved to be one of the most successful. Artek Systems, Inc., of Fayetteville developed a wide-area bar code reader to speed sorting of mail and needed funds to begin mass production of the device. ASTA's $175,000 investment allowed Artek to successfully complete its $900,000 U.S. Postal Service contract for production of 40 bar code readers. The exceptional performance of these units prompted the USPS to order an additional 23 units to completely update its Tampa, Florida, post office, according to J. E. Bass, chairman. Artek will soon be submitting a second bid for a $25 million USPS contract for production of 2,000 units. Artek currently has 12 employees, but that number could jump to 40 or 50 if awarded the second contract, Bass said. The company has also received $652,624 from UAF to adapt the bar code technology for reading magazines and larger envelopes. A prototype is expected by the first of the year. Artek's success has been impressive enough that ASTA is now considering a second investment in the unprecedented amount of $400,000.

Arkansas Technologies (ARTECH): The $150,000 loan to ARTECH of Clarksville was the first investment made by the ASTA Seed Capital Program. ARTECH designs and builds high technology production equipment to help existing manufacturing operations increase flexibility and productivity. Many of its recent projects relate to the brick industry; others include a missile loading system and robotics. The company currently employs 40 people.

Emerging Technologies: This Little Rock company received a $200,000 ASTA investment for development of the world's smallest laser sighting device. The company now holds 60 percent of the national laser/sporting goods market and is #3 moving to #2 in the pointer-audio visual market. It is planning to introduce a construction/hardware product in August at a national hardware show in Chicago. Emerging Technologies employs 45 to 50 people and directly affects and creates jobs in 20 to 30 other Arkansas companies, such as advertising, labeling and machining, according to Martha Reaves, director of marketing and sales.

Incubator Program:

Gorton Hydraulics, Inc.: This company became a client of the East Arkansas Business Incubator System in September of 1989, and because of its successful progress it is expected to graduate from the facility by fall. Gorton Hydraulics is currently employing four full-time employees and one half-time employee. President Todd Gorton said that the number could possibly increase to nine or 10 by the end of the year, depending on the success of contract bids currently out. This company manufactures custom hydraulic cylinders and repairs hydraulic systems, services which before the company's establishment were not available in the Jonesboro area. Gorton Hydraulics has been able to keep in state business which had previously gone to Memphis or other out-of-state vendors. This company's clients after being drawn to the Jonesboro area have also been exposed to other business services available in the vicinity, Gorton added.

Artek Systems, Inc.: The location of this company in the University of Arkansas at Fayetteville Genesis incubator has played a part in its success highlighted in the Seed Capital Program section.

Small Business Innovation Research Program:

Learning Express, Inc., of Little Rock received Phase II monies totaling $440,000 from the U.S. Department of Health and Human Services for a two-year project to adapt bar code technology for

use in curriculum materials and strategies for children with mild, moderate and severe handicaps. The project is in its final months of Phase II and has resulted in a redesign of existing technology of Texas Instruments. The project has also begun Phase III, negotiating for the manufacture of the hardware and marketing the bar code scanning device and its accompanying software in national and international markets. Learning Express has also recently submitted a new proposal to the National Institutes of Health and the Department of Education for research on a multi-purpose communication system for the disabled.

Engineering Resources, a UAF Genesis business incubator tenant, has received $500,000 in Phase II funding to research the "Biological Production of Methanol from Methane" for the Department of Energy. The project is in the middle of its two-year research schedule. Engineering Resources is also expecting to receive SBIR funding for a second project, "The Biological Production of Hydrogen," in about a week, according to Stephen Adams, vice president.

Other Projects:

National Biotechnology Cooperative: The final report investigating the feasibility of the NBC at the National Center for Toxicological Research at Jefferson has been completed and has determined that the NBC is feasible and desirable to a large number of biotechnology companies. The NBC would serve as a national center for commercialization of biotechnology research. Private and public sources are now being sought for funding of this project.

Arkansas Industry Networks: Funded by a $71,440 grant from the Winthrop Rockefeller Foundation, the Southern Technology Council and ASTA are organizing efforts to form regional networks throughout the state to bring the benefits of networking to Arkansas' manufacturers.

ORGANIZATION. The Arkansas Science & Technology Authority is comprised of a Board of Directors and its staff. The 11-member Board is appointed by the Governor to staggered four-year terms. The Board has a 12-person staff, which includes nine professional and three clerical positions, including the President who is selected by the Board and serves at the pleasure of the Governor.

The Board makes all decisions about allocating funds to projects funded under the Authority's programs. Recommendations are made to the Board by three standing committees made up exclusively of members of the Board. The committees deal with research, investments, and planning.

Staff functions are divided into two programatic and two support areas. The programatic divisions are research and finance; the support divisions are information and fiscal.

The finance division is primarily responsible for business-oriented programs and is headed by the **Vice President Finance**. The Seed Capital Investment Program is managed by the **Finance Program Manager**. The SBIR Assistance Program is managed by the **Research Program Manager**. Responsibility for the Business Incubator Program is shared by the Research Program Manager and Vice President Finance. Finance division programs are overseen by the Board's Investment Committee.

The research division is responsible for research-oriented programs and is headed by the **Vice President Research**. The Vice President Research manages the Basic and Applied Research Grant Programs and the Centers for Applied Technology Program with the assistance of the **Program Coordinator**. The Vice President Research also monitors the Research and Development Tax Credits requested by private enterprises for matching the grants with cash or new equipment. Research division programs are overseen by the Board's Research Committee, which has available to it a 10-member Science Advisory Committee.

The information division is managed by the **Vice President Information**, who is responsible for a variety of activities. These include managing the Authority's special demonstration project, the National Biotechnology Cooperative; providing liaison with the state legislature and Arkansas' Congressional delegation, and supervising the Authority's data collection and analysis, coordination, and planning activities. The Communications Program Manager is responsible for all external communications and public relations activities for the Authority. The Information division is overseen by the Board's Planning Committee.

The **President** is the chief executive officer and has overall responsibility for the Authority's programs and support functions. Fiscal and administrative activities are managed by the **Fiscal Officer**, who also manages the office support staff.

C. EXTERNAL ANALYSIS

The ASTA Board of Directors examined information about economic development and technolgy development activities external to the Arkansas Science & Technology Authority. Some of the activities examined are conducted by agencies inside the state, others are conducted in other states and countries.

INSIDE ARKANSAS. There are a variety of of economic development programs operated by the state. It is important for the Board of Directors to understand the goals of these other progrgams and how they relate to the programs of ASTA.

The analysis of these programs is based on the over simplification that economic well being is a function of three factors: the preparation of people, the availability of capital, and the development of technology. Additionally, it is useful to consider economic development as being defined by different stages of development, including community development, production maturation and diversity of the economy, business development, business innovation, technology development, and scientific research.

The preparation of people through education and training is primarilly the mission of the Departments of Education and Higher Education. While this is of general importance to economic well being, the specific importance is found in the following programs: (1) industrial training and (2) industrial coordinators of the Vocational and Technical Education Division of the Department of Education, (3) the Industrial Training Program of the Arkansas Industrial Development Commission in cooperation with the Vocational and Technical Education Division of the Department of Education, and (4) the economic development program at the Department of Higher Education, which builds on the public service mission of the institutions of higher learning.

The availability of capital is the mission of the Arkansas Industrial Development Commission, the Arkansas Development Finance Authority, and the Arkansas Science & Technology Authority. These state sources of capital supplement private sources of capital, such as banks, and complement federal sources, such as the Small Business Administration and the Farmers Home Administration. Taken together, there are seven kinds of capital, basicly for education, research and development, seed funds, venture funds, investments, long-term debt, and infrastructure. These can be provided by a variety of public and private sources and involve differing levels of risk and rates of return. The state, public finance programs of specific interest are: (1) Act 9 bonds for manufacturing plants issued by communities; (2) long-term, fixed-rate, low interest bonds issued for manufacturing plants by the Arkansas Development Finance Authority; seed capital investment funds for scientific and technological projects administered by the Arkansas Science & Technology Authority; infrastructure funds and the Community Development Block Grant Funds both administered by the Arkansas Industrial

The development of technology is the mission of the Arkansas Science & Technology Authority and is also incorporated into the research and public service mission of the institutions of higher learning. The programs of specific interest include the Centers for Applied Technology Program, Basic and Applied Research Grant Programs, the Technology Development Program all administered by the Arkansas Science & Technology Authority and the Arkansas Center for Technology Transfer, funded by the Department of Higher Education at the University of Arkansas, Fayetteville.

In addition, economic development can be described as a progression of steps. These steps impose a certain logic on the factors that constitute economic well being and suggest a sequence of economic development activities. These include activities involving community development, industrial develop-

ment, business development, technology development, and scientific research. Other economic development programs fit into these efforts and include programs like the Department of Higher Education's economic development program, the Science & Tchnology Authority's Business Incubator Program, The Industrial Development Commission's established industries and minority business efforts, and the State Small Business Development Centers.

The relationship of these various state programs is illustrated in the following figure which shows the programs in the context of people, capital, and technology, and the economic development process.

Arkansas Economic Development Programs

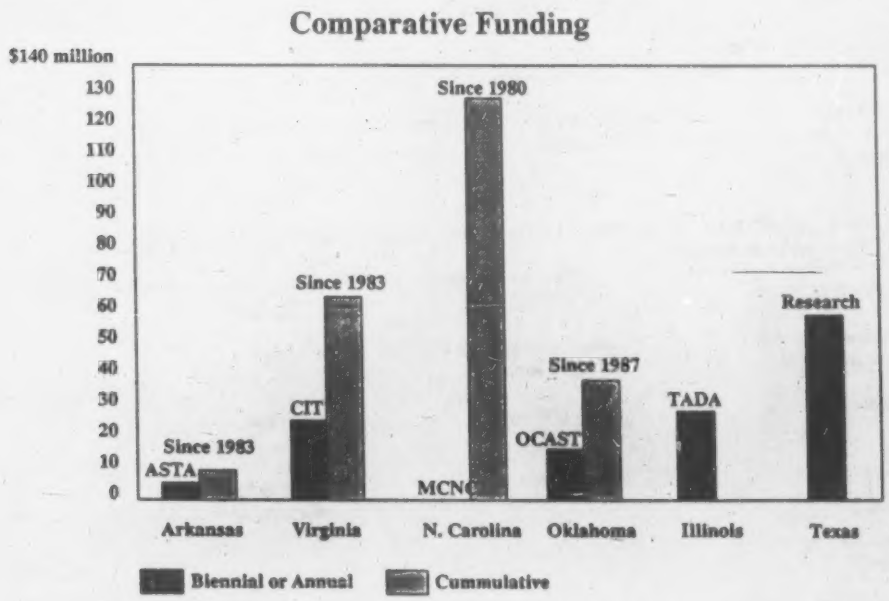
	Serve People	Provide Capital	Develop Technology
Community Development			
CDBG (Community Assistance)		AIDC	
Community Development	AIDC		
Housing Finance		ADFA	
Spec Building Financing		ADFA	
Established Industries			
Expansion of Existing Firms	AIDC		
Quality Management	AIDC		
VoTech Training			
(Industrial Coordinators)	VoTech		
Marketing			
National	AIDC		
International	AIDC		
Export Finance		ADFA	
Applied Research			ASTA
Technology Transfer			ASTA
Technology Transfer			DHE
Recruit New Industry			
Recruit New Industry	AIDC		
Industrial Development	AIDC		
Investment Tax Credit		AIDC	
Enterprise Zone	AIDC		
Infrastructure Fund		AIDC	
Ind. Training Program	AIDC		
Manufacturing Plant Financing		ADFA	
Business Development			
Minority Business	AIDC		
Small Business Clearinghouse	AIDC		
Business Incubators	ASTA		
Seed Capital		ASTA	
Business Training	SBDC		
Loan Packaging	SBDC		
Business Assistance	DHE		
Technology Development			
Technology Development			ASTA
Scientific Research			
Basic Research			ASTA
Centers for Applied Tech.			ASTA

AIDC: Arkansas Industrial Development Commission
ADFA: Arkansas Development Finance Authority
DHE: Department of Higher Education
Votech: Vocational and Technical Education Divison of the Department of Education
SBDC: Small Business Development Commission

OUTSIDE ARKANSAS. The Board also found that the state's technology development effort had not set its sights high enough. Other states are operating the same kinds of programs that ASTA is operating, and the other states are putting more resources into their programs. This means that even while Arkansas is being innovative in its efforts to move its economy forward, other states are moving ahead faster. This point was driven home by information from Oklahoma, a state that imported Arkansas' technology development legislation and which in 1989 invested more than has been invested in ASTA since its creation in 1983.

The programs operated by the Arkansas Science & Technology Authority are similar to programs operated in other states. The principal difference is that the programs eleswhere, sometimes modeled after those in Arkansas, are better financed. This is illustrated in the following bar chart that compares funding of the Arkansas Science & Technology Authority to similar organizations and programs in other states.

Figure 4.



Besides funding, it is also possible to compare the innovation and technology strategies used in Arkansas to those used in other states. David Osborne identifies 21 strategies for state economic development in his recent publication "State Technology Programs: A Preliminary Analysis of Lessons Learned" (1989). The 21 strategies are divided among four general thrusts:

1. Building the research base,
2. Transferring technological advances,
3. Supporting new enterprise development, and
4. Deploying new technologies to existing manufacturers.

His work provides an excellent outline of strategies, insights to lessons learned elsewhere, and opportunities to improve existing programs and add new programs in Arkansas.

In considering options, he offers some important guidelines:

1. Consider comprehensive strategies,
2. Isolate the problem to be solved and ask, "Can government solve it?"
3. Focus on changing the culture, not on individualprojects,
4. Invest, don't spend,
5. Set measures of performance, and
6. Get agreement on long-range goals.

This last point about goals is of particular interest. Osborne illustrates the different emphasis on the goals of government, higher education, and industry. These differences are repeated in Table 2 in outline form.

TABLE 2. SAMPLE DIFFERENT GOALS OF GOVERNMENT, HIGHER EDUCATION, AND BUSINESS.

GOVERNMENT	UNIVERSITY	BUSINESS
-enhance research base in state	-acquire additional research support	-accomplish specific research goals
-create jobs	-train graduate students	-find promising graduate students to hire
-enhance productivity	enhance facilities	-develop long-term relationship with faculty
-enhance business growth		

Source: Osborne (1989)

Osborne's strategies should be viewed in the broader, global context of the 1990s. This context might be provided by "The Japan that Can Say 'No'" which is a monograph by two Japanese, Akio Morita and Shintaro Ishihara. Their basic premise is that Japan has overtaken the United States in industrial production. Japan has technology that is unique in the world; the U.S plays what they call money games. One result, they claim, is that the U.S. economy is without substance because Americans have forgotten how to produce goods.

They make a series of observations about the United States, summarized in the following paragraphs.

There are three types of creativity, those related to

1. Discovery,
2. Product planning and development, and
3. Marketing.

They believe that the United States is outstanding at research, that is, the creativity of discovery, but that the United States lags behind Japan in product development and marketing.

They believe that Japan is superior at using new technology in developing businesses, and they note the different relationships between industry and government in the two countries. There is, for instance, no U.S. counterpart to the Japanese Ministry of International Trade and Industry (MITI).

They give examples of Japan's technological and quality superiority, which they appear to trace to the low educational level of employees in the United States. They believe that there is more meaning to work in Japan, and more investment in industrial education programs.

Interestingly, they note the historical prejudice and cultural narrowness in the United States, which they indicate hold no solutions to the problems which the United States faces. Their perspective implies international prejudice, but it is clear that there are other domestic prejudices that the United States has not overcome.

There are critics who take issue with some facets of the report. There are some points, however, that strike close to the mark. Those points warrant close attention to see if they might be converted to long-term advantages. The following are worthy of consideration and complement Osborne's technology development strategies.

1. Technology has value in the economy and gives the economy substance. The United States needs to give greater emphasis to the development of technology, especially in the form of ew products and improved production.
2. Opportunities to build new businesses around new technology need to be generated.
3. Government probably needs to play a greater role in technology commercialization. The United States should consider the creation of a counterpart to MITI.
4. The United States needs to invest more in its work force, particularly in education and training.
5. The United States must overcome its historical prejudice. There is an overwhelming need to bring racial minorities and women into the science and engineering professions.

With this international context in mind, let us return to Osborne's 21 strategies, which are listed in Table 3.

TABLE 3. OSBORNE'S 21 STRATEGIES.

R. BUILDING THE RESEARCH BASE

1. FUNDING ADDITIONAL RESEARCH*
2. RECRUITING RESEARCH
3. ESTABLISHING UNIVERSITY RESEARCH PARKS
4. ENACTING TAX INCENTIVES*

T. TRANSFERRING TECHNOLOGICAL ADVANCES

1. CHANGING THE CULTURE OF ACADEMIA
2. CREATING INDUSTRY-UNIVERSITY RESEARCH CENTERS*
3. AWARDING MATCHING GRANTS*
4. CREATING BROKER ORGANIZATIONS**
5. CREATING INTERSTITIAL RESEARCH INSTITUTIONS
6. CATALYZING INDUSTRY RESEARCH CONSORTIA
7. CREATING TECHNOLOGY TRANSFER ORGANIZATIONS**
8. ESTABLISHING INDUSTRIAL RESEARCH PARKS

N. SUPPORTING NEW ENTERPRISE DEVELOPMENT

1. ENSURING RISK CAPITAL*
2. CREATING BUSINESS INCUBATORS*
3. ASSISTING MANAGEMENT OF TECH-BASED START UPS
4. CREATING SUPPORT NETWORKS

M. SUPPORTING DEPLOYMENT OF NEW TECHNOLOGY BY EXISTING MANUFACTURERS

1. CREATING INDUSTRIAL EXTENSION SERVICES
2. SUPPORTING MANUFACTURING INSTITUTES
3. SETTING UP LOAN FUNDS, BACKED WITH TECHNICAL ASSISTANCE
4. CREATING REGIONAL, SECTORAL NETWORKS*
5. FUNDING LABOR-MANAGEMENT COMMITTEES

Source: Osborne (1989)

A single asterisk (*) marks strategies for which the Arkansas Science & Technology Authority has operating programs. Two asterisks (**) mark those strategies for which ASTA was apparently created. There are other entities that are implementing some of the strategies, notably the Arkansas Center for Technology Transfer at the University of Arkansas at Fayetteville.

D. EVALUATION

ASTA's Board of Directors was surveyed to determine which of Osborne's strategies are most important to the state. Nine of 11 Board members participated in the survey. The survey also asked them to rate four additional strategies related to supporting education. These strategies are listed in Table 4.

TABLE 4. ASTA'S FOUR EDUCATIONAL STRATEGIES.

E. SUPPORTING MATH, SCIENCE, AND ENGINEERING EDUCATION

1. ESTABLISHING A CENTER FOR SCIENCE EDUCATION
2. SUPPORTING ENGINEERING FOR THE DELTA
3. SUPPORTING HIGHER EDUCATION INFRASTRUCTURE FOR SCIENCE AND ENGINEERING
4. SUPPLEMENTING HIGHER EDUCATION MANPOWER

The survey results are summarized in Figures 1 and 2. Figure 1 shows the importance of the strategy to the state as a whole, while Figure 2 shows the priority to ASTA.

There are six columns in Figures 1 and 2. The six columns describes, respectively:

1. Reflects the alpha numeric reference to the strategies listed in Tables 2 and 3,
2. The strategy,
3. The survey score for the strategy (the sum of the votes for the highest and second highest importance rankings),
4. The score represented as a bar chart,
5. Votes indicating the strategy should be an ASTA priority, and
6. Votes indicating the strategy should not be an ASTA priority.

An expanded version of Osborne's and ASTA's strategies is provided for reference in the appendix. This appendix shows where ASTA's existing programs fit into Osborne's organization of strategies and where opportunities for new and expanded technology-development programs might exist for ASTA.

Figure 5:

ASTA Board Ranking of the Importance of Technology Development Strategies for Arkansas

		Overall Importance to Arkansas		ASTA or Not	
No.	Strategy	Score	Score as Bar Chart	ASTA	Not ASTA
R.2.	Recruiting	9.0		8	1 Not ASTA
T.6	Consortia	8.0		8	
E.3	Infrastructure	8.0		3	1 Not ASTA
T.2	Joint Research	7.0		7	
R.1.	Funding	7.0		7	
T.3.	Matching Grants	7.0		7	
N.1.	Risk Captial	7.0		5	1 Not ASTA
E.4.	S & T Manpower	7.0		1	2 Not ASTA
T.8.	Industrial Res. Parks	6.0		5	2 Not ASTA
R.3.	Research Parks	6.0		5	
R.4.	Tax Incentives	5.0		5	1 Not ASTA
M.4.	Industrial Networks	5.0		4	2 Not ASTA
E.2.	Delta Tech	5.0		4	1 Not ASTA
E.1.	Science Ed Center	5.0		4	1 Not ASTA
N.2.	Incubators	4.0		4	1 Not ASTA
M.2.	Manufacturing Institutes	4.0		4	2 Not ASTA
N.4.	Support Networks	4.0		4	2 Not ASTA
N.3.	Management Assist.	4.0		3	1 Not ASTA
M.1.	Extension Services	4.0		3	3 Not ASTA
T.1.	Culture	4.0		2	1 Not ASTA
T.7.	TT Organization	3.0		3	1 Not ASTA
T.5.	Research Institutes	3.0		2	1 Not ASTA
T.4.	Broker	1.0		2	1 Not ASTA
M.3.	Loan Funds	1.0		1	3 Not ASTA
M.5.	Labor Management	1.0			2 Not ASTA

Figure 6:

ASTA Board Ranking of the Importance of Technology Development Strategies for Arkansas

No.	Strategy	Overall Importance to Arkansas: Score	Score as Bar Chart	ASTA or Not: ASTA	Not ASTA
R.2.	Recruiting	9.0		8	1 Not ASTA
T.6	Consortia	8.0		8	
T.3	Matching Grants	7.0		7	
T.2	Joint Research	7.0		7	
R.1.	Funding	7.0		7	
N.1.	Risk Captial	7.0		5	1 Not ASTA
R.3.	Research Parks	6.0		5	
T.8.	Industrial Res. Parks	6.0		5	2 Not ASTA
R.4.	Tax Incentives	5.0		5	1 Not ASTA
M.4.	Industrial Networks	5.0		4	2 Not ASTA
E.1.	Science Ed Center	5.0		4	1 Not ASTA
E.2.	Delta Tech	5.0		4	1 Not ASTA
M.2.	Manufacturing Institutes	4.0		4	2 Not ASTA
N.2.	Incubators	4.0		4	1 Not ASTA
N.4.	Support Networks	4.0		4	2 Not ASTA
E.3.	Infrastructure	8.0		3	1 Not ASTA
N.3.	Management Assist.	4.0		3	1 Not ASTA
M.1.	Extension Services	4.0		3	3 Not ASTA
T.7.	TT Organization	3.0		3	1 Not ASTA
T.1.	Culture	4.0		2	1 Not ASTA
T.5.	Research Institutes	3.0		2	1 Not ASTA
T.4.	Broker	1.0		2	1 Not ASTA
E.4.	S & T Manpower	7.0		1	2 Not ASTA
M.3.	Loan Funds	1.0		1	3 Not ASTA
M.5.	Labor Management	1.0			2 Not ASTA

The Plan for the 1991-1993 Biennium and Beyond: Appendix I

ASTA's Strategic Vision: Strategies, Programs, Observations and Opportunities

R. Building the Research Base

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
1. Funding additional research	Basic Research Grant Program	a. Research priorities different b. Connections to economic development not automatic c. Research requires other parts of the innovation system	Increase basic research funding
2. Recruiting federal or private-sector research institutions	Special Projects/ SBIR	a. Positive results are a byproduct of an effective investment strategy	Establish a Washington presence
3. Establishing university research parks	Proposed Coordinating Office	a. There are too many; among them the results are mixed	
4. Enacting tax incentives for corporate research	R&D Tax Credit	a. Generally problematic	Exempt purchases of R&D equipment by universities from sales tax

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T. Transferring Technological Advances

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
1. Changing the culture of academia		a. Must change the reward system of higher education	
2. Creating industry-university research centers	Centers/EPSCoR	a. Business must lead	Find business leaders Fund product development centers
3. Awarding matching grants to industry-university projects	Applied Research Grant Program	a. Appear to produce superior results	Expand applied research funding
4. Creating broker/facilitator organizations to bring industry and university resources together	[ASTA]	a. Act as nerve centers for: • Matching grants • Grants to business development organizations • Incubator grants • Industrial extension • Grants for technology-related education • Regional seed capital funds	Expand funding to provide supplemental support for SBDCs, 10/10 efforts and regional technology-development offices at incubators
5. Creating research institutions that fill the gap between academia and business (i.e., an industrial technology institute)		a. Should universities run such institutes? b. Are institutes market driven? [Note that Japan has MITI.] c. Do a few projects very well	Fund product development projects with industry focus and technology demonstrations for industry

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T. Transferring Technological Advances (continued)

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
6. Acting as catalyst and partner in the formation of industry research consortia.		a. Federal government more appropriate	
7. Creating separate technology transfer organizations specifi cally designed to identify promising research results and assist in their commercialization	[ASTA]	a. Modest compared to Japan b. Use university-based contest to: • Find research with commercial potential • Build firm around idea • Recruit entrepreneur • Raise capital	Create a private, not-for-profit development arm Help license university technology
8. Creating industrial research parks near research universities		a. These are real estate deals b. They must fit with other programs	

N. Supporting New Enterprise Development as a Means to Commercialize New Technologies

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
1. Ensuring an adequate supply of risk capital	Seed Capital Investment Program	a. There are mixed goals b. The goal should be to change the nature of the marketplace, not just to make loans c. Funds should be leveraged d. The typical fund is $10 million	Increase ASTA seed capital fund, which is too small for demand
2. Creating small business incubators to increase the survival rate of technology start-ups	Business Incubator Program	a. They appear to be achieving their goals • management assistance • technological help • research grants • seed capital • venture capital • banking connections b. They provide a link to local industries • shared equipment • marketing networks • training • comprehensive business assistance centers	Continue support for ASTA business incubators Expand funding to support comprehensive technology-development efforts Make incubators a focal point for industrial networks

N. Supporting New Enterpise Development as a Means to Commercialize New Technologies (continued)

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
3. Develop management assistance groups to work with tech start-ups		a. Management is far more important than capital b. Management assistance works but its vision is too limited c. The most successful work with relatively few clients • screen carefully • find firms with growth potential • help with: business plans marketing financing accounting labor/management • they have credibility	Develop a management assistance program for tech-based start-ups and support through SBDCs
4. Creating support networks for technology-intensive start-ups		a. Advanced technology centers that provide • incubators • management assistance • matching grants • local seed capital • referrals b. The problem is that generally such programs operate piecemeal from the capitol, independent from each other with no synergy.	Expand support for incubators and give them this mission in partnership with SBDCs

M. Supporting Deployment of New Process Technologies by Existing Manufacturers

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
1. Creating industrial extension services		a. There are 4 kinds: PASSIVE respond to client requests BROKERS refer clients to other programs, etc. ACTIVE visit client plants, analyze needs, help decide and install equipment COMPREHENSIVE deals with most client needs b. Active seems far more effective, but most are university based, which at times minimized their effectiveness. This is due to distrust of academics, few of whom are given incentives or salary for helping clients. c. Most extension services are not comprehensive. Comprehensive programs typically provide • grants • 3 kinds of experts -production -training -labor relations	Establishing such a service by supporting the Arkansas Center for Technology Transfer, GIT, and other university-based technology programs through ASTA, which could perhaps forge a link between them and, with other ASTA resources, make them comprehensive

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M. Supporting Deployment of New Process Technologies by Existing Manufacturers (continued)

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
1. Creating industrial extension services (continued)		d. Extension services should be developed independent of universities, but with ties to university expertise	
2. Creating or supporting research institutions on manufacturing that double as consulting organizations to manufacturing businesses		a. These are supported by large clients	
3. Setting up a loan fund for mature manufacturers, backed by technical assistance	Proposed Management and Tech Assessment Program	a. Such help would not be for firms in serious trouble b. The program would offer technical and management assistance, diagnosis, and suggestions for management, marketing, and production c. Massachusetts experience: 2 years, 19 loans for $4.4 million	Identify such firms Develop a loan fund as a joint effort between ASTA, SBDCs, ADFA and AIDC

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M. Supporting Deployment of New Process Technologies by Existing Manufacturers (continued)

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
4. Creating regional networks within the same industry to work together to meet technology needs	Special Projects	a. These are networks of many small firms b. Need to find clusters c. Northern Italy is the model • Trade associations handle: PAYROLL LEGAL BILLING ACCOUNTING INVENTORY CONTROL INSURANCE also: INDUSTRIAL PARKS FACTORY SPACE JOB TRAINING BULK PURCHASING EXPORT MARKETING MANAGEMENT TRAINING d. Owner/operators concentrate on what they know best: PRODUCTION e. The government supports ARTISAN VILLAGES f. The government seed financed 6 sector SERVICE CENTERS	Create model networks; there is a pilot project underway; emphasis perhaps should be shifted to AIDC, except for technology development networks at ASTA Establish a loan-guarantee program involving AIDC, ASTA and ADFA

M. Supporting Deployment of New Process Technologies by Existing Manufacturers (continued)

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
4. Creating regional networks within the same industry to work together to meet technology needs (continued)		g. These are also small-business-loan-guarantee consortia that offer a 50% GUARANTEE and supporting programs to buy down the interest rate	
5. Funding labor-management committees to change the internal culture and organization of manufacturing firms			

E. Supporting Math, Science, and Engineering Education

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
1. Establishing a center for science education		a. Science and math teachers need a source of assistance • $500 minigrants for classroom projects • clearinghouse for ideas and assistance • toll-free number for quick help • research programs to develop, validate and disseminate information for teaching science	Fund a science education center Build incentives, for faculty and science teachers to collaborate, into ASTA's existing research grant programs
		b. Teach science for Arkansas • get best and brightest college science and engineering students to spend two years in the Arkansas Science Corps (like peace corps)	
		c. Support museum exhibits • grants to colleges and universities for displays at Mid-America museum • science in a shoe box science teacher minigrant projects	Build support for museum exhibits into existing programs Provide for the production of small teaching aids in research projects

E. Supporting Math, Science, and Engineering Education (continued)

Strategies	Existing Programs	Observations, Questions and Potential Problems	Opportunities
2. Supporting engineering for the Delta		a. Provide engineering scholarships with 1 year of service required for each year of support b. Provide a cost-sharing engineering coop program for Delta firms	
3. Supporting higher education infrastructure for science and engineering		a. Maker equipment grant b. Recommend facility construction projects	Expand funding of research grants for equipment
4. Supplementing higher education		a. Make multi-year awards for new research positions at research institutions	Fund ASTA research positions as a new program

The Plan for the 1991-1993 Biennium and Beyond: Appendix II

ASTA's Strategic Vision: Strategies, Programs and Indicators of Success

ASTA's Strategic Vision: Strategies, Programs and Indicators of Success

Strategy	Programs to Activate Strategy	Short-term Indicators of Success	Long-term Indicators of Success
Funding additional research (R.1)	Basic Research Grant Program	Amount of research funds attracted by scientists	Total R&D funds in universities
Recruiting federal or private-sector research institutions (R.2)	SBIR Assistance Program	Total R&D funds from federal agencies participating in SBIR program	
	Corridor Development Project	Number of new products developed, number of new companies, venture capital investments	Number of patents issued, employment, employment growth, total R&D funds in universities
	Coordinating Office (proposed)	Amount of research funds attracted by state campuses	Total R&D funds in universities
Enacting tax incentives for corporate research (R.4)	R&D Tax Credit Program	Value of tax credits issued, number of applied research grants	
Creating industry-university research centers (T.2)	Centers for Applied Technology	Amount of research funds attracted by the centers, amount of private matching funds raised by centers, new products developed	Total R&D funds in universities, number of patents issued

ASTA's Strategic Vision: Strategies, Programs and Indicators of Success (continued)

Strategy	Programs to Activate Strategy	Short-term Indicators of Success	Long-term Indicators of Success
Awarding matching grants to industry-university projects (T.3)	Applied Research Grant Program	Amount of research funds attracted , amount of private matching funds raised by projects	Employment, employment growth, total R&D funds in universities
Creating research institutions that fill the gap between academia and business (T.5)	Technology Development Program	Number of new products developed	Number of patents issued, new companies, employment, employment growth
Creating separate technology transfer organizations specifically designed to identify promising research results and assist in their commercialization (T.7)	Technology Transfer Program	Number of projects funded, number of transfers completed, number of new products developed, return on investment	Number of patents issued, new companies, employment, employment growth
Ensuring an adequate supply of risk capital (N.1)	Seed Capital Investment Program	Number of investments made, number of new products developed, return on investment	Number of patents issued, new companies, employment, employment growth
Creating small business incubators to increase the survival rate of technology start-ups (N.2)	Business Incubator Program	Number of tenant companies, number of employees, number of new products developed, number of companies in which Seed Capital Investments have been made and the associated return on investment	Number of patents issued, new companies, employment, employment growth

ASTA's Strategic Vision: Strategies, Programs and Indicators of Success (continued)

Strategy	Programs to Activate Strategy	Short-term Indicators of Success	Long-term Indicators of Success
Creating small business incubators to increase the survaival rate of technology start-ups (continued) (N.2)	Business Innovation System (modified program)	Number of tenant or client enterprises, number of employees, number of new products developed, number of enterprises participating in other ASTA programs	Number of patents issued, new companies, employment, employment growth
Creating industrial extension services (M.1)	Industrial Extension Service (proposed)	Not identified	Not identified
Creating or support research institutions on manufacturing that double as consulting organizations to manufacture business (M.2)	Manufacturing Institute (proposed)	Not identified	Not identified
Setting up loan fund for mature manufacturers, backed by technical assistance (M.3)	Management and Technology Assistance Program (proposed)	Number of projects undertaken	Employment, long-term employment growth, business failure rate, manufacturing capital investment
Creating regioual networks within the same industry to work together to meet technology needs (M.4)	Arkansas Industrial Network Program (proposed)	Number of networks, number of participating companies	Employment, employment growth

ASTA's Strategic Vision: Strategies, Programs and Indicators of Success (continued)

Strategy	Programs to Activate Strategy	Short-term Indicators of Success	Long-term Indicators of Success
Establishing a center for science education (E.1)	Center for Science Education (proposed)	Number of inquiries handled, number of grants received	Science and engineering student per 1000 population
Supporting engineering for the Delta (E.2)	Science and Engineering Scholarship Program (proposed)	Number of scholarships and public service tours	Number of female and minority scientists and engineers, science and engineering students per 1000 population, science and engineering degrees granted, scientists and engineers in the work force
Supporting higher education infrastructure for science and engineering (E.3)	Science and Engineering Research Infrastructure Program (proposed)	Number and amount of awards for equipment and facilities, the amount of research funds attracted by the campus	Science and engineering students per 1000 population, science and engineering degrees granted, scientists and engineers in the work force, total R&D funds in universities
Supplementing higher education manpower (E.4)	Eminent Scientist and Engineering Program (proposed)	Number of awards, amount of research funds attracted by the campus	Science and engineering students per 1000 population, science and engineering degrees granted, scientists and engineers in the work force, total R&D funds in universities